Final Report for 2005 Virginia - Chesapeake Bay Finfish Ageing

by

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November 30, 2006

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Executive Summary

In this report we present the results of ageing finfish collected from catches made in Virginia's marine waters in 2005. All fish were collected in 2005 by the Virginia Marine Resources Commission's (VMRC) Stock Assessment Program and aged in 2006 at the Center for Quantitative Fisheries Ecology's Age and Growth Laboratory at Old Dominion University. This report is broken down into chapters, one for each of the 13 species we aged. For each species, we present measures of ageing precision and bias, graphs of year-class distributions, and age-length keys. Chapter 14 discuss the results of protocol development for data entry and amanagement.

For three species: summer flounder, *Paralichthys dentatus*, (n=362); striped bass, *Morone saxatilis*, (n=1396); and tautog, *Tautoga onitis*, (n=518) multiple bony structures were used for determining fish age. Scales and otoliths were used to age summer flounder and striped bass, and opercula and otoliths were used to age tautog. Comparing alternative hard parts allowed us to assess their usefulness in determining fish age as well as the relative precision of each structure. Ages were determined from otoliths for the following species collected in Virginia waters during 2005: Atlantic croaker, *Micropogonias undulatus*, (n=333); black drum, *Pogonias cromis*, (n=8); bluefish, *Pomatomus saltatrix*, (n=336); cobia, *Rachycentron canadum*, (n=17); red drum, *Sciaenops ocellatus*, (n=22); spadefish, *Chaetodipterus faber*, (n=236); Spanish mackerel, *Scomberomorous maculates*, (n=360); spot, *Leiostomus xanthurus*, (n=401); spotted seatrout, *Cynoscion nebulosus*, (n=212); and weakfish, *Cynoscion regalis*, (n=756).

In total, we made 13,784 age readings from 6,092 scales, otoliths and opercula collected during 2005. A summary of the age ranges for all species aged is presented in Table I.

Table I. Summary of numbers aged and age ranges for the 13 marine fish species collected for age determination in Virginia during 2005.

Species	Number of Fish	Number of Hard-Parts	Number of Age Readings	Minimum Age	Maximum Age
Atlantic croaker	333	332	764	1	15
black drum	8	8	116	0	6
bluefish	336	335	770	0	11
cobia	17	16	132	0	10
red drum	22	22	144	1	34
spadefish	236	229	558	0	16
Spanish mackerel	360	347	794	0	7
spot	401	400	900	0	6
spotted seatrout	212	212	524	0	6
striped bass	1396	1709	3618	3	23
summer flounder	362	705	1610	0	11
tautog	518	1021	2242	1	16
weakfish	756	756	1612	1	10
Totals	4957	6092	13784		

To enhance our understanding of the population dynamics of fish species in Chesapeake Bay and along the Atlantic coast, we initiated three projects on ageing and population dynamics of finfish species. First, we validated otolith-based ageing and compared otolith- and opercula-based ageing on tautog (*Tautoga onitis*). We found that the otolith-based ageing method could identify tautog as a relatively fast-growing species, which is completely opposite to previous studies which reported tautog as a low-growing fish when opercula-based ageing method was used. This finding has been reported to the VMRC. Second, following the CCA initiative, we proposed a research project on the sheepshead (*Archosargus probatocephalus*) population in the Chesapeake Bay and obtained a grant from VMRC for 2006. We will work closely with the CCA on this project in 2006 and continue it for next three years. Third, we started a collaboration with Maryland DNR to examine effects of otolith- and scale-based ageing of striped bass (*Morone saxatilis*) on estimates of cohort abundance and fishing mortality derived from ADAPT-VPA. The results from this study could promote replacing scale-based ageing with otolith-based ageing. We plan to finish this project by the end of 2006.

As part of our continued public outreach focused at recreational anglers, we again participated in the CCA's Kid's Fishing Day at Lynnhaven Fishing Pier. This was the fifth year our staff volunteered their time to participate in the event. To support other environmental and wildlife agencies, we donated more than 3000 pounds dissected fish to the Wildlife Rescue which is responsible for saving injured animals found by the public.

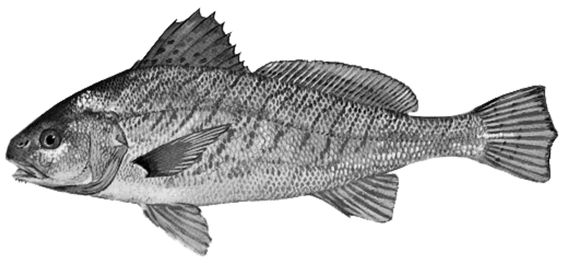
In 2005, we continue to upgrade our Age & Growth Laboratory website, which can be accessed at http://web.odu.edu/fish. The website includes electronic versions of this document along with more detailed explanations of the methods and structures we use in age determination.

Acknowledgements

We thank Roxanne Torres, Laura McCaskill, Mignogne Twine, Khalid Qadwai, and Srujan Baddam for their technical expertise in preparing otoliths, scales, and opercula for age determination. They all put in long hours processing "tons" of fish in our lab. We are also thankful for Dr. William Persons' III hard work on our *Species Updates* and web page. A special note of appreciation to Ron Owens, Troy Thompson, Joanie Beatley, and Myra Thompson, and Tara Bushnoe for their many efforts in this cooperative project. A special thank also goes to Eric Robillard, our former chief technician, for his hard work.

The image on the front cover is an otolith thin-section from a 315 mm (12.4 inch) total length, 5 year-old male spot. The fifth annulus is forming at the edge of the otolith.

Chapter 1
Atlantic Croaker



Micropogonias undulatus

INTRODUCTION

A total of 333 Atlantic croaker, *Micropogonias undulatus*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. The average age was 5.8 years, and the standard deviation and standard error were 2.58 and 0.14, respectively. Fourteen age classes (1 to 13 and 15) were represented, comprising fish from the 1990, 1992-2004 year-classes. Fish from the 1997, 1998, 2001, and 2003 year-classes dominated the sample.

METHODS

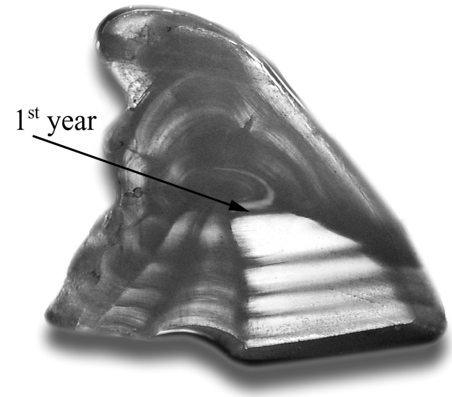
Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. In the lab they were sorted by date of capture, their envelope labels were verified against VMRC's collection data, and each fish was assigned a unique Age and Growth Laboratory identification number. All otoliths were stored dry in labeled cell well plates.

Preparation — Otoliths were processed following the methods described in Barbieri et al. (1994) with a few modifications. Briefly, the left or right sagittal otolith was randomly selected and attached to a glass slide with Aremco's clear Crystalbond™ 509 adhesive. At least two serial transverse sections were cut through the core of each otolith with a Buehler Isomet low-speed saw equipped with a three inch, fine grit Norton diamond-wafering blade. Otolith sections were placed on labeled glass slides and covered with a thin layer of Flo-texx mounting medium, that not only adhered the sections to the slide, but more importantly, provided enhanced contrast and greater readability by increasing light transmission through the sections.

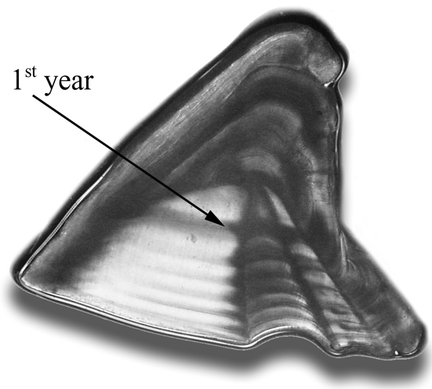
Readings — Sectioned otoliths were aged by two different readers using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 20 times magnification. Each reader aged all of the otolith samples. The ageing criteria reported in Barbieri et al. (1994) were used in age determination, particularly regarding the location of the first annulus (Figure 1).

All samples were aged in chronological order, based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any



(a)



(b)

Figure 1. Otolith cross-sections of a) a 5 year old croaker with a small 1st

systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2003. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

No bias was discovered in any of the self-precision tests of otolith age estimates, with both readers equally able to reproduce the ages of previously read samples (Both readers had 0% CVs). There was also 93.4 percent agreement with an average CV of 1.4% between reader age estimates. Figure 2 illustrates the between readers' precision of age estimates.

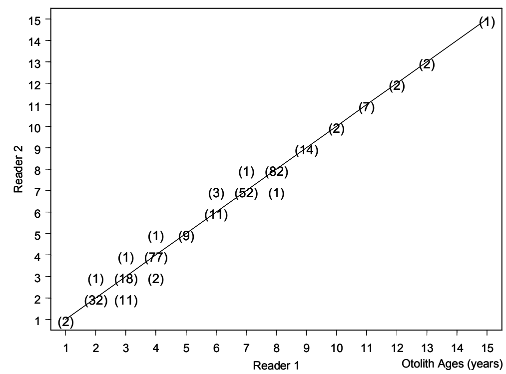


Figure 2. Between-reader

Of the 332 fish aged with otoliths (Otoliths for one fish was lost), 14 age classes (1 to 13 and 15) were represented (Table 1). The average age for the sample was 5.8 years, and the standard deviation and standard error were 2.58 and 0.14, respectively.

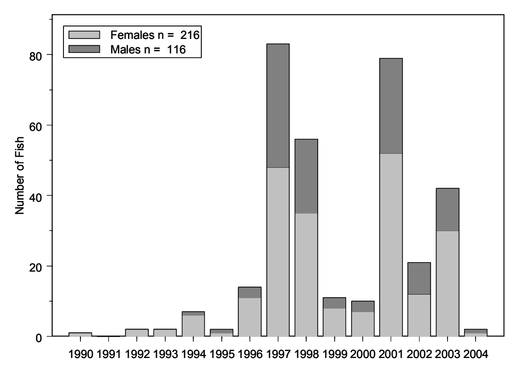


Figure 3. Year-class distribution for Atlantic croaker collected for ageing in 2005. Distributions are broken down by sex.

Year-class data (Figure 3) indicate that recruitment into the fishery begins at age 1, but large numbers are not seen until age 2, which corresponds to the 2003 year-class for Atlantic croaker collected in 2005. While the ratio of males to females shows an overall higher number of females, both sexes show trends of high abundance for the 1997, 1998, 2001, and 2003 year-classes.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Barbieri, L.R., M.E. Chittenden, and C.M. Jones. 1994. Age, growth, and mortality of Atlantic croaker, *Micropogonias undulatus*, in the Chesapeake Bay region, with a discussion of the apparent geographical changes in population dynamics. Fish. Bull. 92:1-12.

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

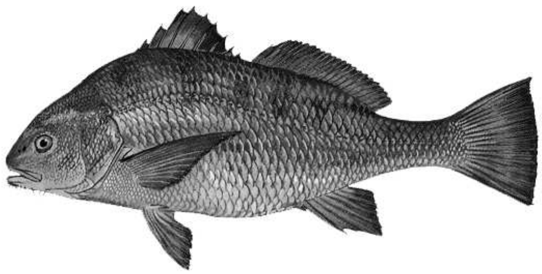
Table 1. The number of Atlantic croaker assigned to each total length-at-age category for 332 fish sampled for age determination in Virginia during 2005 (Length not reported for 1 fish).

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	15	Totals
8 - 8.99	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
9 - 9.99	2	15	4	0	0	0	0	0	0	0	0	0	0	0	21
10 - 10.99	0	15	7	3	0	0	1	0	0	0	0	0	0	0	26
11 - 11.99	0	8	5	15	0	0	2	0	0	0	0	0	0	0	30
12 - 12.99	0	3	5	41	2	3	7	8	1	0	0	0	0	0	70
13 - 13.99	0	0	0	11	6	1	14	17	2	1	0	0	0	0	52
14 - 14.99	0	0	0	4	2	2	12	29	1	0	1	0	0	0	51
15 - 15.99	0	0	0	4	0	1	12	12	5	0	3	1	0	0	38
16 - 16.99	0	0	0	0	0	1	4	7	2	1	1	0	0	0	16
17 - 17.99	0	0	0	0	0	3	2	6	0	0	2	0	2	0	15
18 - 18.99	0	0	0	0	0	0	1	1	1	0	0	1	0	1	5
19 - 19.99	0	0	0	0	0	0	0	3	2	0	0	0	0	0	5
20 - 20.99	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Totals	2	42	21	78	10	11	56	83	14	2	7	2	2	1	331

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-class, based on otolith ages for Atlantic croaker sampled for age determination in Virginia during 2005 (Length not reported for 1 fish

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	15	N
8 - 8.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1
9 - 9.99	0.095	0.714	0.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	21
10 - 10.99	0.000	0.577	0.269	0.115	0.000	0.000	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	26
11 - 11.99	0.000	0.267	0.167	0.500	0.000	0.000	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	30
12 - 12.99	0.000	0.043	0.071	0.586	0.029	0.043	0.100	0.114	0.014	0.000	0.000	0.000	0.000	0.000	70
13 - 13.99	0.000	0.000	0.000	0.212	0.115	0.019	0.269	0.327	0.038	0.019	0.000	0.000	0.000	0.000	52
14 - 14.99	0.000	0.000	0.000	0.078	0.039	0.039	0.235	0.569	0.020	0.000	0.020	0.000	0.000	0.000	51
15 - 15.99	0.000	0.000	0.000	0.105	0.000	0.026	0.316	0.316	0.132	0.000	0.079	0.026	0.000	0.000	38
16 - 16.99	0.000	0.000	0.000	0.000	0.000	0.063	0.250	0.438	0.125	0.063	0.063	0.000	0.000	0.000	16
17 - 17.99	0.000	0.000	0.000	0.000	0.000	0.200	0.133	0.400	0.000	0.000	0.133	0.000	0.133	0.000	15
18 - 18.99	0.000	0.000	0.000	0.000	0.000	0.000	0.200	0.200	0.200	0.000	0.000	0.200	0.000	0.200	5
19 - 19.99	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.600	0.400	0.000	0.000	0.000	0.000	0.000	5
20 - 20.99	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1
											Sample Size				331

Chapter 2
Black Drum



Pogonias cromis

INTRODUCTION

A total of 8 black drum, *Pogonias cromis*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. The average age of the sample was 1.8 years, with a standard deviation of 2.71 and a standard error of 0.96. The youngest fish was 0 year old and the oldest fish was 6 years old, representing the 2005 and 1999 year-classes, respectively.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. In the lab they were sorted by date of capture, their envelope labels were verified against VMRC's collection data, and each fish was assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in their original VMRC coin envelopes.

Preparation — Otoliths were processed for ageing following the methods described in Bobko (1991) and Jones and Wells (1998). Briefly, at least two serial transverse sections were cut through the nucleus of each otolith with a Buehler Isomet low-speed saw equipped with a three inch, fine grit Norton diamond-wafering blade. Otolith sections were placed on labeled glass slides and covered with a thin layer of Flo-texx mounting medium, that not only adhered the sections to the slide, but more importantly, provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — Sectioned otoliths were aged by two different readers using a Leica MZ-12 dissecting microscope with transmitted light at between 8 and 20 times magnification (Figure 1). Each reader aged all of the otolith samples.

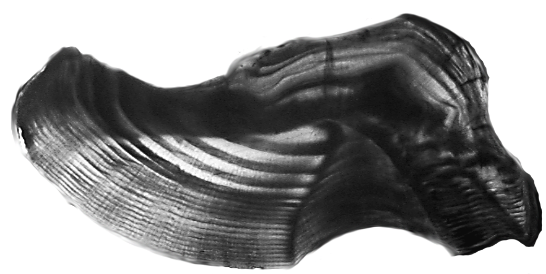


Figure 1. Otolith thin-section from a 20 year-old black drum.

All samples were aged in chronological order, based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, both readers aged all fish for second time to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

No bias was discovered in any of the self-precision tests of otolith age estimates, with both readers equally able to reproduce the ages of previously read samples (Both readers had 0% CVs). There was also 100 percent agreement between reader age estimates. Figure 2 illustrates the between readers' precision of age estimates.

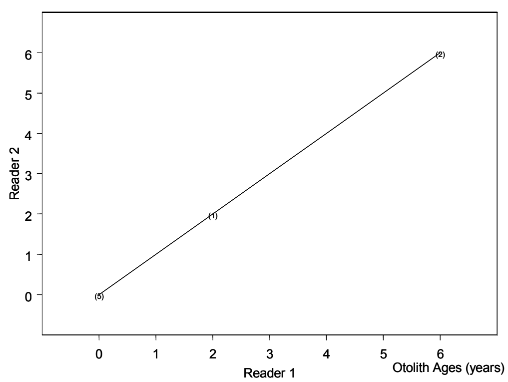


Figure 2. Between-reader comparison of otoliths age estimates for black drum.

Of the 8 fish aged with otoliths, 3 age classes were represented (Table 1). The average age of the sample was 1.8 years, with a standard deviation of 2.71 and a standard error of 0.96. The youngest fish was a 0 year old and the oldest fish was 6 years old, representing the 2005 and 1999 year-classes, respectively. Year-class data (Figure 3) show that the sample was comprised of 3 year-classes, comprising fish from the 1999, 2003 and 2005 year-classes, with fish primarily from the 2005 year-class.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

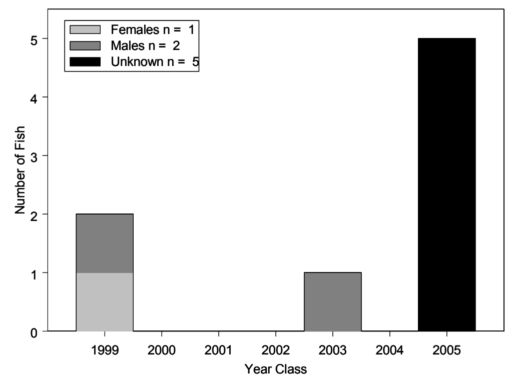


Figure 3. Year-class distribution for black drum collected for ageing in 2005. Distributions are broken down by sex.

REFERENCES

Bobko, S. J. 1991. Age, growth, and reproduction of black drum, *Pogonias cromis*, in Virginia. M.S. thesis. Old Dominion University, Norfolk, VA.

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

Jones, C.J. 1998. Report on black drum studies for the period 1990-1996. Study of important recreational fishes in the Chesapeake Bay. Federal Aid in Sport Fish Restoration Act project F-88-R-3.

Jones, C.J. and B.K. Wells. 1998. Age, growth, and mortality of black drum, *Pogonias cromis*, in the Chesapeake Bay region. Fish. Bull. 96:451-461.

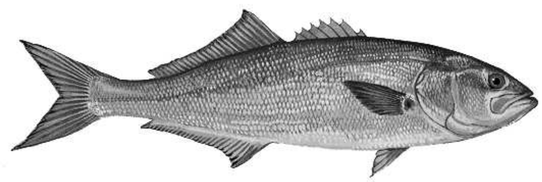
Table 1. The number of black drum assigned to each total length-at-age category for 8 fish sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years)			
	0	2	6	Totals
6 - 6.99	1	0	0	1
7 - 7.99	2	0	0	2
8 - 8.99	2	0	0	2
21 - 21.99	0	1	0	1
30 - 30.99	0	0	2	2
Totals	5	1	2	8

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for black drum sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years)			
	0	2	6	N
6 - 6.99	1.000	0.000	0.000	1
7 - 7.99	1.000	0.000	0.000	2
8 - 8.99	1.000	0.000	0.000	2
21 - 21.99	0.000	1.000	0.000	1
30 - 30.99	0.000	0.000	1.000	2
		Samples Size		8

Chapter 3
Bluefish



Pomatomus saltatrix

INTRODUCTION

A total of 336 bluefish, *Pomatomus saltatrix*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. We were unable to age one fish due to the poor quality of its otoliths. The average age for the 335 aged fish was 2.1 years, and the standard deviation and standard error were 1.65 and 0.09, respectively. Twelve age classes (0 to 11) were represented, comprising fish from the 1994 to 2005 year-classes. The 2003 and 2004 year-classes dominated the sample.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in labeled cell well plates.

Preparation — We used a bake and thin-section technique to process bluefish otoliths for age determination. Otolith preparation began by randomly selecting either the right or left otolith. Each otolith was mounted with Crystal Bond onto a standard microscope slide with its distal surface orientated upwards. Once mounted, a small mark was placed on the otolith surface directly above the otolith focus. The slide, with attached otolith, was then secured to an Isomet saw equipped with two diamond wafering blades separated by a 0.5 mm spacer, which was slightly smaller in diameter than the diamond blades. The otolith was positioned so that the wafering blades straddled each side of the otolith focus ink mark. It was crucial that this cut be perpendicular to the long axis of the otolith. Failure to do so resulted in "broadening" and distortion of winter growth zones. A proper cut resulted in annuli that were clearly defined and delineated. Once cut, the otolith section was placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400^{o}C. Baking time was otolith size dependent and gauged by color, with a light caramel color desired. Once a suitable color was reached the baked thin-section was placed on a labeled glass slide and covered with a thin layer of Flo-texx mounting medium, that not only adhered the sections to the slide, but more importantly, provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — Two different readers using a LEICA MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification aged all sectioned otoliths (Figure 1). If an otolith was properly sectioned the sulcal groove came to a sharp point within the middle of the focus. Typically the first year's annulus was found by locating the focus of the otolith, which was characterized as a visually distinct dark oblong region found in the center of the otolith. The first year's annulus had the highest visibility proximal to the focus along the edge of the sulcal groove. Once located, the first year's annulus was followed outward from the sulcal groove towards the dorsal perimeter of the otolith. Often, but not always, the first year was associated with a very distinct crenellation on the dorsal surface and a prominent protrusion on the ventral surface. Unfortunately both these landmarks had a tendency to become less prominent in older fish.

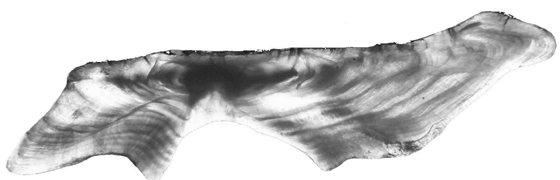


Figure 1. Otolith thin-section from a 850mm TL 8 year-old female bluefish.

Even with the bake and thin-section technique, interpretation of the growth zones from the otoliths of young bluefish was difficult. Rapid growth within the first year of life prevents a sharp delineation between opaque and translucent zones. When the exact location of the first year was not clearly evident, and the otolith had been sectioned accurately, a combination of surface landscape (1st year crenellation) and the position of the second annuli were used to help determine the position of the first annulus.

What appeared to be "double annuli" were occasionally observed in bluefish four years of age and older. This annulus formation typically occurred within years 4 to 7, and was characterized by distinct and separate annuli in extremely close proximity to each other. We do not know if the formation of these double annuli were two separate annuli, or in fact only one, but they seemed to occur during times of reduced growth after maturation. "Double annuli" were considered to be one annulus when both marks joined to form a central origin. The origins being the sulcal groove and at the outer peripheral edge of the otolith. If these annuli did not meet to form a central origin they were considered two annuli, and counted as such.

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

The measurement of reader self-precision was low for both readers (Reader 1's CV = 14.4% and Reader 2's CV = 10.9%). There was evidence of systematic disagreement between Reader 1 and Reader 2 (test of symmetry, $\chi^2 = 38.8$, df = 14, $P = 0.0004$). Figure 2 illustrates the between readers' precision of age estimates. The average coefficient of variation (CV) of 13.7% was significant. The between-reader agreement for scale for one year or less was 98.5% of all aged fish. Such a high agreement between the readers and the high CVs were partially due to the sample dominated by younger fish.

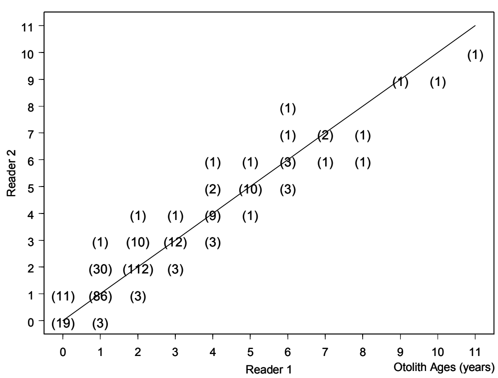


Figure 2. Between-reader comparison

Of the 335 fish aged with otoliths 12 age classes were represented (Table 1). The average age for the sample was 2.1 years, and the standard deviation and standard error were 1.65 and 0.09, respectively.

Year-class data (Figure 3) indicates that recruitment into the fishery began at age 0, which corresponded to the 2005 year-class for bluefish caught in 2005. One and two-year-old fish were the dominant year-class in the 2005 sample.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's

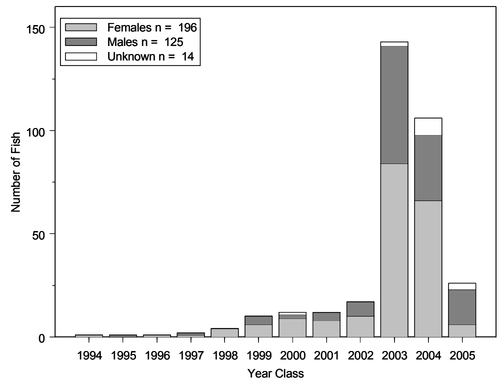


Figure 3. Year-class distribution for bluefish collected for ageing in 2005. Distribution is broken down by sex.

stratified sampling of landings by total length inch intervals.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

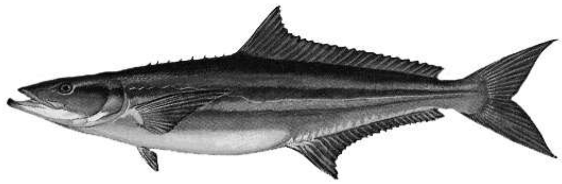
Table 1. The number of bluefish assigned to each total length-at-age category for 335 fish collected for age determination in Virginia in 2005 (length not reported for 2 fish).

Length						Age (years)							
1-inch	0	1	2	3	4	5	6	7	8	9	10	11	
intervals													**Totals**
10 - 10.99	2	2	0	0	0	0	0	0	0	0	0	0	4
11 - 11.99	2	2	0	0	0	0	0	0	0	0	0	0	4
12 - 12.99	1	9	1	0	0	0	0	0	0	0	0	0	11
13 - 13.99	14	11	2	0	0	0	0	0	0	0	0	0	27
14 - 14.99	5	15	7	0	0	0	0	0	0	0	0	0	27
15 - 15.99	2	23	11	0	0	0	0	0	0	0	0	0	36
16 - 16.99	0	20	17	0	0	0	0	0	0	0	0	0	37
17 - 17.99	0	17	31	0	0	0	0	1	0	0	0	0	49
18 - 18.99	0	5	29	0	0	0	0	0	0	0	0	0	34
19 - 19.99	0	2	10	0	0	0	0	0	0	0	0	0	12
20 - 20.99	0	0	14	3	0	0	0	0	0	0	0	0	17
21 - 21.99	0	0	10	0	0	0	0	0	0	0	0	0	10
22 - 22.99	0	0	5	2	0	0	0	0	0	0	0	0	7
23 - 23.99	0	0	2	2	0	0	0	0	0	0	0	0	4
24 - 24.99	0	0	2	1	0	0	0	0	0	0	0	0	3
25 - 25.99	0	0	2	2	0	0	0	0	0	0	0	0	4
27 - 27.99	0	0	0	3	0	0	0	0	0	0	0	0	3
28 - 28.99	0	0	0	1	0	0	1	0	0	0	0	0	2
29 - 29.99	0	0	0	0	8	1	0	0	0	0	0	0	9
30 - 30.99	0	0	0	3	1	2	2	0	0	0	0	0	8
31 - 31.99	0	0	0	0	2	5	1	0	0	0	0	0	8
32 - 32.99	0	0	0	0	0	3	2	0	0	0	0	0	5
33 - 33.99	0	0	0	0	1	0	1	2	2	0	0	0	6
34 - 34.99	0	0	0	0	0	1	2	1	0	0	0	0	4
35 - 35.99	0	0	0	0	0	0	1	0	0	0	1	0	2
Totals	26	106	143	17	12	12	10	4	2	0	1	0	333

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-class, based on otolith ages, for bluefish collected for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 0	1	2	3	4	5	6	7	8	9	10	11	N
10 - 10.99	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4
11 - 11.99	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4
12 - 12.99	0.091	0.818	0.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	11
13 - 13.99	0.519	0.407	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27
14 - 14.99	0.185	0.556	0.259	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27
15 - 15.99	0.056	0.639	0.306	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	36
16 - 16.99	0.000	0.541	0.459	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	37
17 - 17.99	0.000	0.347	0.633	0.000	0.000	0.000	0.000	0.020	0.000	0.000	0.000	0.000	49
18 - 18.99	0.000	0.147	0.853	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	34
19 - 19.99	0.000	0.167	0.833	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12
20 - 20.99	0.000	0.000	0.824	0.176	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	17
21 - 21.99	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	10
22 - 22.99	0.000	0.000	0.714	0.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7
23 - 23.99	0.000	0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4
24 - 24.99	0.000	0.000	0.667	0.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3
25 - 25.99	0.000	0.000	0.500	0.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4
27 - 27.99	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3
28 - 28.99	0.000	0.000	0.000	0.500	0.000	0.000	0.500	0.000	0.000	0.000	0.000	0.000	2
29 - 29.99	0.000	0.000	0.000	0.000	0.889	0.111	0.000	0.000	0.000	0.000	0.000	0.000	9
30 - 30.99	0.000	0.000	0.000	0.375	0.125	0.250	0.250	0.000	0.000	0.000	0.000	0.000	8
31 - 31.99	0.000	0.000	0.000	0.000	0.250	0.625	0.125	0.000	0.000	0.000	0.000	0.000	8
32 - 32.99	0.000	0.000	0.000	0.000	0.000	0.600	0.400	0.000	0.000	0.000	0.000	0.000	5
33 - 33.99	0.000	0.000	0.000	0.000	0.167	0.000	0.167	0.333	0.333	0.000	0.000	0.000	6
34 - 34.99	0.000	0.000	0.000	0.000	0.000	0.250	0.500	0.250	0.000	0.000	0.000	0.000	4
35 - 35.99	0.000	0.000	0.000	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.500	0.000	2
									Sample Size				333

Chapter 4
Cobia



Rachycentron canadum

INTRODUCTION

A total of 17 cobia, *Rachycentron canadum*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. We were unable to age one fish due to the poor quality of its otoliths. The average age of the sample was 4.9 years, and the standard deviation and standard error were 2.31 and 0.58, respectively. Seven age classes (0, 3 to 7, and 10) were represented, comprising fish from the 1995, 1998 to 2002, and 2005 year-classes. The 1999 and 2002 year-class dominated the sample.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in labeled cell well plates.

Preparation — Individual otoliths were placed into 14 mm x 5 mm x 3 mm wells (Ladd Industries silicon rubber mold) filled with Loctite adhesive. Each otolith was rolled around in the Loctite to remove all trapped air bubbles and ensure complete coverage of the otolith surface. The otoliths were oriented sulcal side down with the long axis of the otolith exactly parallel with the long axis of the mold well. Once the otoliths were properly oriented, the mold was placed under UV light and left to solidify overnight. Once dry, each embedded otolith was removed from the mold and mounted with Crystal Bond onto a standard microscope slide. Once mounted, a small mark was placed on the otolith surface directly above the otolith focus. The slide, with attached otolith, was then secured to an Isomet saw equipped with two diamond wafering blades separated by a 0.5 mm spacer, which was slightly smaller in diameter than the diamond blades. The otolith was positioned so that the wafering blades straddled each side of the focus ink mark. The glass slide was adjusted to ensure that the blades were exactly perpendicular to the long axis of the otolith. The otolith wafer section was viewed under a dissecting microscope to determine which side (cut surface) of the otolith was closer to the focus. The otolith section was mounted best-side up onto a glass slide with Crystal Bond. The section was then lightly polished on a Buehler Ecomet 3 variable speed grinder-polisher with Mark V Laboratory 30-micron polishing film. After drying, a thin layer of Flo-texx mounting medium was applied over the polished otolith surface, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — Two different readers using a LEICA MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification aged all sectioned otoliths (Figure 1). Both age readers aged all of the otolith samples.

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

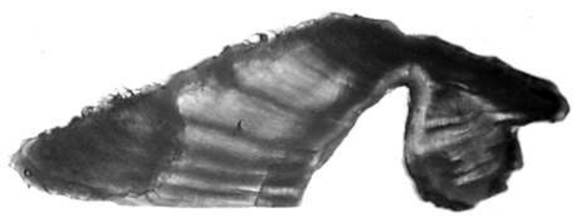


Figure 1. Otolith thin-section from a 1524mm TL 6 year old cobia.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, both readers aged all fish a second time to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

The measurement of reader self-precision was not high for both readers (Reader 1's CV = 0% and Reader 2's CV = 0.5%). There was no evidence of systematic disagreement between Reader 1 and Reader 2 (test of symmetry, $\chi^2 = 1$, df = 1, $P = 0.3173$). Figure 2 illustrates the between readers' precision of age estimates. The average

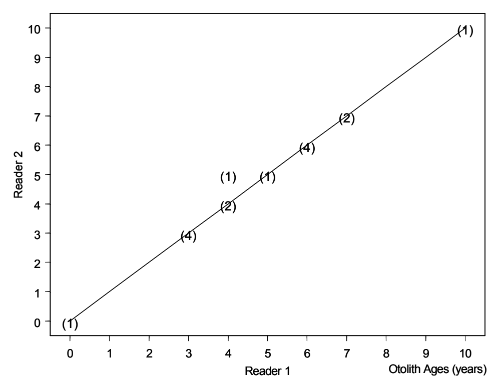


Figure 2. Between-reader

coefficient of variation (CV) of 1.1% was not significant.

Of the 16 fish aged, 7 age classes were represented (Table 1). The average age of the sample was 4.9 years, and the standard deviation and standard error were 2.31 and 0.58, respectively.

Year-class data (Figure 3) indicates that recruitment into the fishery begins at age 0, which corresponds to the 2005 year-class for cobia caught in 2005. The year-class 1999 and 2002 dominated the sample.

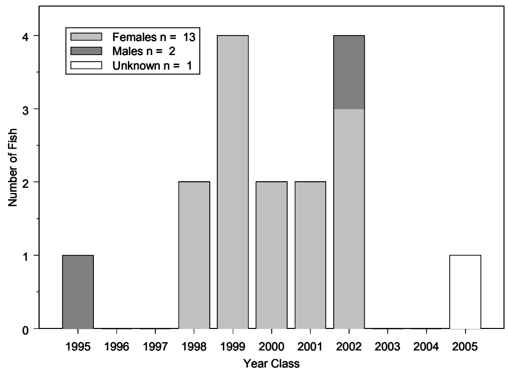


Figure 3. Year-class distribution for cobia collected for ageing in 2005. Distribution is broken down by sex.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Franks, J.S., J.R. Warren, and M.V. Buchanan. 1999. Age and growth of cobia, Rachycentron canadum, from the northeastern Gulf of Mexico. Fish. Bull. 97:459-471.

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

Table 1. The number of cobia assigned to each total length-at-age category for 16 fish sampled for age determination in Virginia during 2005

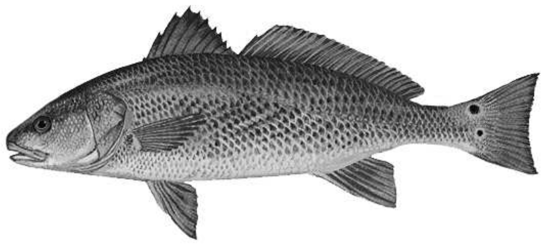
Length 1-inch intervals	Age (years) 0	3	4	5	6	7	10	Totals
13-13.99	1	0	0	0	0	0	0	1
33-33.99	0	1	0	0	0	0	0	1
38-38.99	0	1	0	0	0	0	0	1
39-39.99	0	1	0	1	0	0	0	2
41-41.99	0	1	0	0	0	0	0	1
47-47.99	0	0	1	0	0	0	0	1
48-48.99	0	0	0	1	0	0	1	2
50 - 50.99	0	0	1	0	0	0	0	1
52 - 52.99	0	0	0	0	0	1	0	1
53 - 53.99	0	0	0	0	2	0	0	2
54 - 54.99	0	0	0	0	0	1	0	1
56-56.99	0	0	0	0	1	0	0	1
61-61.99	0	0	0	0	1	0	0	1
Totals	1	4	2	2	4	2	1	16

Table 2. Age-Length key, as proportions-at-age in each 1 in length-interval, based on otolith ages for cobia sampled for age determination in Virginia during 2005

Length 1-inch intervals	Age (years) 0	3	4	5	6	7	10	N
13-13.99	1.000	0.000	0.000	0.000	0.000	0.000	0.000	1
33-33.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1
38-38.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1
39-39.99	0.000	0.500	0.000	0.500	0.000	0.000	0.000	2
41-41.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1
47-47.99	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1
48-48.99	0.000	0.000	0.000	0.500	0.000	0.000	0.500	2
50 - 50.99	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1
52 - 52.99	0.000	0.000	0.000	0.000	0.000	1.000	0.000	1
53 - 53.99	0.000	0.000	0.000	0.000	1.000	0.000	0.000	2
54 - 54.99	0.000	0.000	0.000	0.000	0.000	1.000	0.000	1
56-56.99	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1
61-61.99	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1
							Sample Size	16

Chapter 5
Red Drum
Sciaenops ocellatus

INTRODUCTION



A total of 22 red drum, *Sciaenops ocellatus*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. The average age of the sample was 2.6 years, and the standard deviation and standard error were 7.03 and 1.50, respectively. Three age classes (1, 2 and 34) were represented, comprising fish from the 1971, 2003 and 2004 year-classes. One-year-old fish were the dominant year-class in the 2005 sample.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in their original labeled coin envelopes.

Preparation — Otoliths were processed for ageing following the methods described in Bobko (1991) for black drum. Briefly, otoliths were mounted on glass slides with Crystal Bond. At least two serial transverse sections were cut through the nucleus of each otolith with a Buehler Isomet low-speed saw equipped with a three inch, fine grit Norton diamond-wafering blade. After drying, a thin layer of Flo-texx mounting medium was applied to the otolith section to increase light transmission through the translucent zones, which provided enhanced contrast and greater readability.

Readings — Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 20 times magnification (Figure 1).

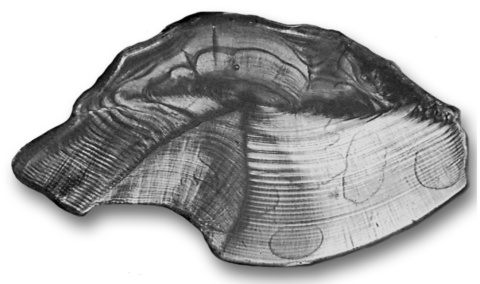


Figure 1. Otolith thin-section from 26 year old red drum.

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Red drum ages were based on a biological birthdate of September 1, while year-class assignment was based on a January 1 annual birthdate. Red drum were treated in this manner because of the timing of spawning and the fact that the first annulus is not seen on an otolith until a fish's second spring. For example, a red drum that was born in September of 1997 and captured in March of 1999 would not have any visible annuli on its otoliths, but would be aged as a 1 year-old fish since it lived beyond one September (September 1998). But this 1 year-old fish caught in 1999 would be mistakenly assigned to the 1998 year-class. In order to properly assign the fish to its correct year-class, 1997, a January birthdate was used which would make the fish 2 years-old (since the fish lived past January 1998 and 1999) and year-class would be assigned correctly.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, both readers aged all 22 fish for second time to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

Measurements of reader self-precision were high, with both readers able to reproduce 100 % of the ages of previously read otoliths. Figure 2 illustrates the between readers' precision of age estimates. There was 100% agreement between readers.

Of the 22 fish aged with otoliths, 3 age classes were represented (Table 1). The average age of the sample was 2.6 years, and the standard deviation and standard error were 7.03 and 1.50, respectively.

Year-class data (Figure 3) indicate that the 2004 year-class dominated the sample. Indicative of the trend in the recreational fishing, very few older fish were collected in 2005.

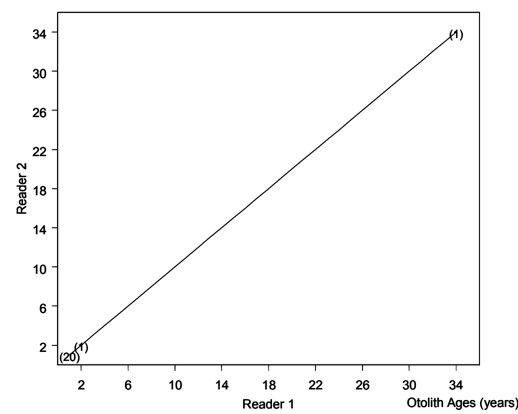


Figure 2. Between-reader comparison of otolith age estimates for red drum

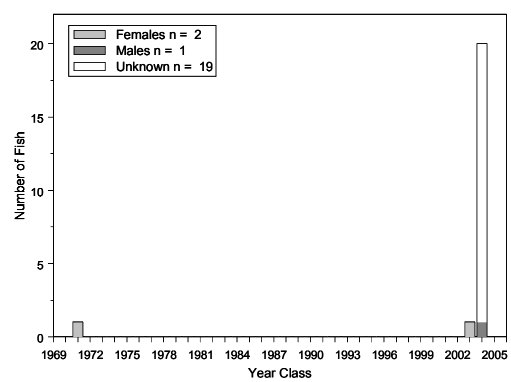


Figure 3. Year-class distribution for red drum collected for ageing in 2005. Distribution is broken down by sex.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Bobko, S. J. 1991. Age, growth, and reproduction of black drum, *Pogonias cromis*, in Virginia. M.S. thesis. Old Dominion University, Norfolk, VA.

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

Table 1. The number of red drum assigned to each total length-at-age category for 22 fish sampled for age determination in Virginia during 2005 (Length not reported for 2 fish).

Length 1-inch intervals	Age (years)			
	1	2	34	Totals
16-16.99	3	0	0	3
17-17.99	6	0	0	6
18 - 18.99	9	0	0	9
25 - 25.99	0	1	0	1
46 - 46.99	0	0	1	1
Totals	18	1	1	20

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for red drum sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years)			
	1	2	34	N
16-16.99	1.000	0.000	0.000	3
17-17.99	1.000	0.000	0.000	6
18 - 18.99	1.000	0.000	0.000	9
25 - 25.99	0.000	1.000	0.000	1
46 - 46.99	0.000	0.000	1.000	1
		Sample Size		20

Chapter 6
Atlantic Spadefish

Chaetodipterus faber

INTRODUCTION

A total of 236 spadefish, *Chaetodipterus faber*, was collected for age and growth analysis in 2005. We were unable to either process or age seven fish due to the poor quality of their otoliths. The average age of the sample was 2.8 years, and the standard deviation and standard error were 2.25 and 0.15, respectively. Thirteen age classes (0 to 7, 9, 11 to 13, and 16) were represented, comprising fish from the 1989, 1992 to 1994, 1996, 1998 to 2005 year-classes.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in labeled cell well trays.

Preparation — Otoliths were processed for ageing using a bake and thin-section technique. Preparation began by randomly selecting either the right or left otolith. The otolith was mounted with Crystal Bond onto a standard microscope slide with its distal surface orientated upwards. Once mounted, a small mark was placed on the otolith surface directly above the otolith focus. The slide, with attached otolith, was then secured to a Buehler Isomet low-speed saw equipped with two fine grit Norton diamond-wafering blades separated by a 0.5 mm spacer, which was slightly smaller in diameter than the diamond blades. The otolith was positioned so that the wafering blades straddled each side of the otolith focus ink mark. It was crucial that this cut be perpendicular to the long axis of the otolith. Failure to do so resulted in "broadening" and distortion of winter growth zones. A proper cut resulted in annuli that were clearly defined and delineated. Once cut, the otolith section was placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400°C. Baking time was otolith size dependent and gauged by color, with a light caramel color desired. Once a suitable color was reached the baked thin-section was placed on a labeled glass slide and covered with a thin layer of Flo-texx mounting medium, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

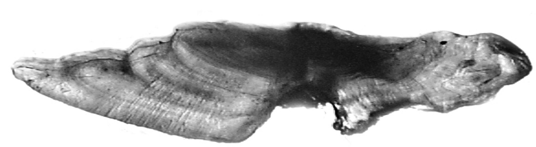


Figure 1. Sectioned otolith from a 3-year-old female spadefish.

Readings — Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 1).

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2003. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

Measurements of reader self-precision were high, with both readers able to reproduce the ages of previously read otoliths (Reader 1's CV = 1.9% and Reader 2's CV = 5.0%). Figure 2 illustrates the between readers' precision of age estimates. There was evidence of systematic disagreement between Reader 1 and Reader 2 (test of symmetry, $\chi^2 = 27.4$, df = 9, $P = 0.0012$). The average coefficient of variation (CV) of 5.3% was considered not to be significant and lower than the CV of 5.0% reported in 2004.

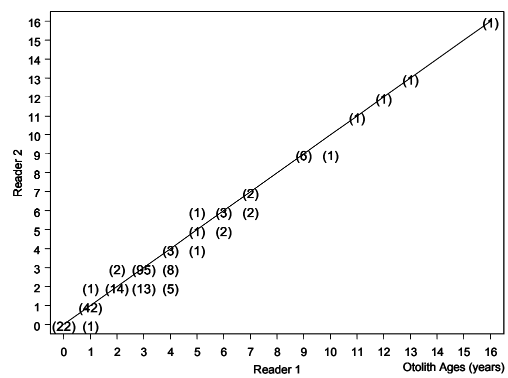


Figure 2. Between-reader comparison of otolith age estimates for spadefish.

Of the 229 fish aged with otoliths, 13 age classes were represented (Table 1). The average age of the sample was 2.8 years, and the standard deviation and standard error were 2.25 and 0.15, respectively. Year-class data (Figure 3) indicate that the 2002 year-class dominated the sample.

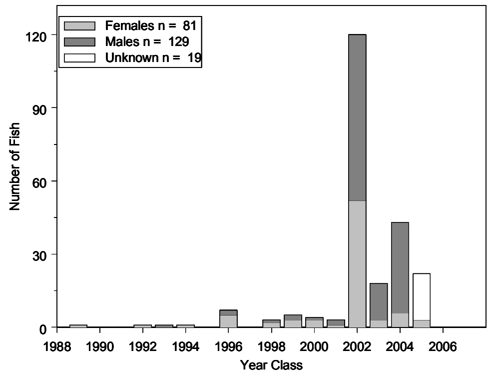


Figure 3. Year-class distribution for spadefish collected for ageing in 2005. Distribution is broken down by sex.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

Kimura, D.K. 1980. Likelihood methods for the von Bertalanffy growth curve. Fish. Bull. 77:765-776.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

Table 1. The number of spadefish assigned to each total length-at-age category for 229 fish collected for age determination in Virginia during 2005.

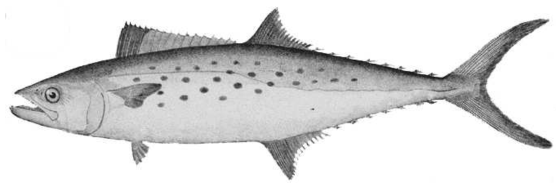
Length 1-inch intervals	Age (years) 0	1	2	3	4	5	6	7	9	11	12	13	16	Totals
3 - 3.99	3	0	0	0	0	0	0	0	0	0	0	0	0	3
4 - 4.99	18	0	0	0	0	0	0	0	0	0	0	0	0	18
5 - 5.99	1	22	1	0	0	0	0	0	0	0	0	0	0	24
6 - 6.99	0	14	0	0	0	0	0	0	0	0	0	0	0	14
7 - 7.99	0	5	0	0	0	0	0	0	0	0	0	0	0	5
8 - 8.99	0	2	1	9	0	0	0	0	0	0	0	0	0	12
9 - 9.99	0	0	6	16	0	0	0	0	0	0	0	0	0	22
10 - 10.99	0	0	6	21	0	0	0	1	0	0	0	0	0	28
11 - 11.99	0	0	1	27	0	0	1	0	0	0	0	0	0	29
12 - 12.99	0	0	0	18	0	0	0	0	0	0	0	0	0	18
13 - 13.99	0	0	1	11	0	0	1	0	0	0	0	0	0	13
14 - 14.99	0	0	1	6	0	0	0	0	0	0	0	0	0	7
15 - 15.99	0	0	1	5	1	0	0	0	0	0	0	0	0	7
16 - 16.99	0	0	0	2	1	0	0	0	0	0	0	0	0	3
17 - 17.99	0	0	0	2	0	1	1	0	0	0	0	0	0	4
18 - 18.99	0	0	0	1	1	0	0	1	0	0	0	0	0	3
19 - 19.99	0	0	0	2	0	1	0	0	0	0	0	0	0	3
20 - 20.99	0	0	0	0	0	2	2	1	1	0	0	0	0	6
21 - 21.99	0	0	0	0	0	0	0	0	1	0	1	0	0	2
22 - 22.99	0	0	0	0	0	0	0	0	3	1	0	0	0	4
23 - 23.99	0	0	0	0	0	0	0	0	1	0	0	1	1	3
24 - 24.99	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Totals	22	43	18	120	3	4	5	3	7	1	1	1	1	229

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for spadefish sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 0	1	2	3	4	5	6	7	9	11	12	13	16	N
3 - 3.99	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
4 - 4.99	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
5 - 5.99	0.04	0.92	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	24
6 - 6.99	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14
7 - 7.99	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5
8 - 8.99	0.00	0.17	0.08	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12
9 - 9.99	0.00	0.00	0.27	0.73	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22
10 - 10.99	0.00	0.00	0.21	0.75	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	28
11 - 11.99	0.00	0.00	0.03	0.93	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	29
12 - 12.99	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18
13 - 13.99	0.00	0.00	0.08	0.85	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	13
14 - 14.99	0.00	0.00	0.14	0.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
15 - 15.99	0.00	0.00	0.14	0.71	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7
16 - 16.99	0.00	0.00	0.00	0.67	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
17 - 17.99	0.00	0.00	0.00	0.50	0.00	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00	4
18 - 18.99	0.00	0.00	0.00	0.33	0.33	0.00	0.00	0.33	0.00	0.00	0.00	0.00	0.00	3
19 - 19.99	0.00	0.00	0.00	0.67	0.00	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3
20 - 20.99	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.17	0.17	0.00	0.00	0.00	0.00	6
21 - 21.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	2
22 - 22.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.25	0.00	0.00	0.00	4
23 - 23.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.33	0.33	3
24 - 24.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1
											Sample Size			229

Chapter 7

Spanish Mackerel



Scomberomorous maculatus

INTRODUCTION

A total of 360 Spanish mackerel, *Scomberomorous maculatus*, was collected by the Virginia Marine Resource Commission (VMRC) Stock Assessment Program and the Center for Quantitative Fisheries Ecology (CQFE) in 2005. Age was determined for 347 Spanish mackerel using sagittal otoliths. The average age for the 347 fish was 1.4 years, and the standard deviation and standard error were 1.09 and 0.06, respectively. Eight age classes were observed (0 to 7), representing fish from the 1998 through 2005 year-classes.

METHODS

Handling of collection — All otoliths and associated data were transferred to the Center for Quantitative Fisheries Ecology's Age and Growth Laboratory as they were collected. In the lab they were sorted by date of capture, their envelope labels verified against VMRC's collection data, and each fish was assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in labeled cell well plates.

Preparation — Otoliths from fish were processed using an Age and Growth Laboratory thin section technique modified to deal with the fragile nature of Spanish mackerel otoliths. Briefly, an otolith was first embedded in a 9.5 mm x 4.5 mm x 4.5 mm silicon mold well with Loctite 349 photo-active adhesive. The mold was placed under ultraviolet light to cure and harden the Loctite. The embedded otolith was removed from the Silicon mold and the location of the core of the otolith was then marked with an extra fine point permanent marker. A thin transverse section was made using a Buelher Isomet saw equipped with two high concentration Norton diamond wafering blades separated by a 0.4 mm steel spacer. The otolith section was mounted best-side up onto a glass slide with Crystal Bond. The section was then lightly polished on a Buehler Ecomet 3 variable speed grinder-polisher with Mark V Laboratory 30-micron polishing film. The thin-section was then covered with a thin layer of Flo-texx mounting medium, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — By convention, a birth date of January 1 is assigned to all Northern Hemisphere fish species. We use a system of age determination that assigns age class according to the date of sacrifice with respect to this international accepted birth date and the timing of annulus formation. Although an otolith annulus is actually the combination of an opaque and translucent band, when ageing otoliths we actually enumerate only the opaque bands, but still refer to them as annuli. Spanish mackerel otolith annulus formation occurs between the months of April and June, with younger fish tending to lay down annuli earlier than older fish. Fish age is written first followed by the actual number of annuli visible listed within parentheses (e.g., 3(3)). The presence of a "+" after the number in the parentheses indicates new growth, or "plus growth" visible on the structure's margin. Using this method, a fish sacrificed in January before annulus formation with three visible annuli would be assigned the same age, 4(3+), as a fish with four visible annuli sacrificed in August after annulus formation, 4(4+). Year-class is then assigned once the reader determines the fish's age and takes into account the year of capture.

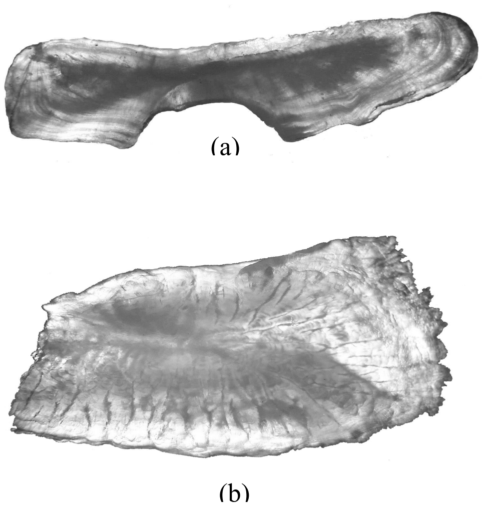


Figure 1. A three year old spanish mackerel otolith from a 0.6 kg male a) thin-section b) whole otolith with part of the tip broken off.

Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with polarized transmitted light at between 8 and 40 times magnification. The first annulus on sectioned otoliths was often quite distant from the core, with subsequent annuli regularly spaced along the sulcal groove out towards the proximal (inner-face) edge of the otolith (Figures 1 and 2).

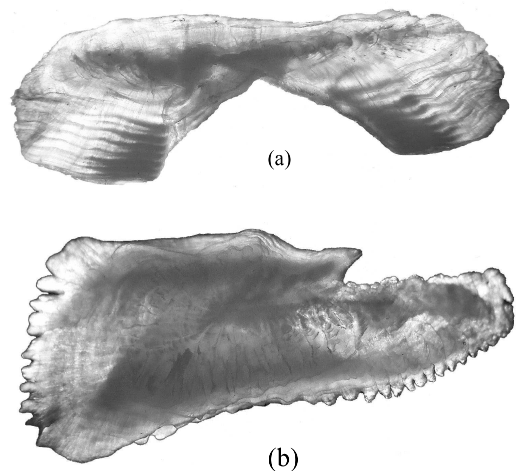


Figure 2. An eight year old Spanish mackerel otolith from a 1 kg female a) thin-section b) whole otolith.

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged the otoliths of 50 randomly selected fish previously aged in 2003. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

The measurement of reader self-precision was fair for Reader 2 (Reader 1's CV = 11.6% and Reader 2's CV = 4.4%). The average between-reader coefficient of variation (CV) of 6.4% was considered relatively high. Figure 3 illustrates the between readers' precision of age estimates. There was evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, χ^2 = 25.7, df = 8, *P* = 0.0012). The between-reader agreement for scale for one year or less was 98.6% of all aged fish. The high agreement and the high CV for Read 1 were partially due to the sample dominated by younger fish.

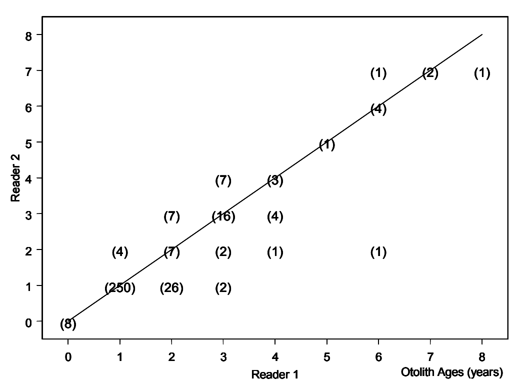


Figure 3. Between-reader comparison of otolith age estimates for Spanish mackerel.

Of the 347 Spanish mackerel aged with otoliths, eight age classes were represented (Table 3). The average age was 1.4 year old, and the standard deviation and standard error were 1.08 and 0.06, respectively. Year-class data (Figure 4) show that the fishery was comprised of eight year-classes, comprising fish from the 1998 through 2005 year-classes, with fish primarily from the 2004 year-classes.

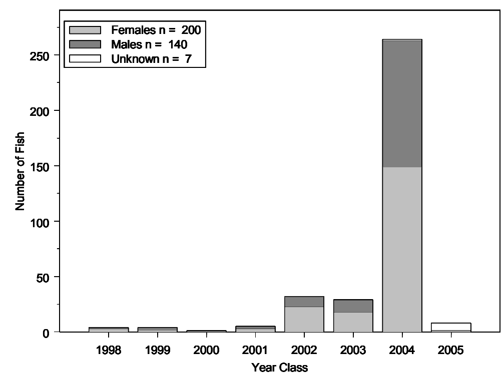


Figure 4. Year-class frequency distribution for Spanish mackerel collected for ageing in 2005. Distribution for otolith ages is broken down by sex.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for etermining the consistency of age terminations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analyzing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

Kimura, D.K. 1980. Likelihood methods for the von Bertalanffy growth curve. Fish. Bull. 77:765-776.

Murphy E.O., R.S. Birdsong, J.A. Musick. 1997. Fishes of the Chesapeake Bay. Smithsonian Institute Press. Washington and London.

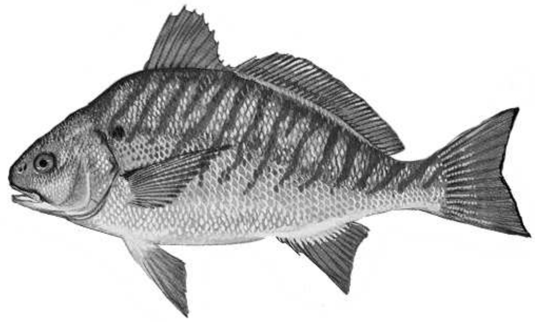
Table 1. The number of Spanish mackerel assigned to each total length-at-age category for 347 fish sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years)								
	0	1	2	3	4	5	6	7	Totals
7 - 7.99	1	0	0	0	0	0	0	0	1
8 - 8.99	2	0	0	0	0	0	0	0	2
9 - 9.99	1	0	0	0	0	0	0	0	1
11 - 11.99	2	1	0	0	0	0	0	0	3
12 - 12.99	1	14	0	0	0	0	0	0	15
13 - 13.99	0	32	0	0	0	0	0	0	32
14 - 14.99	1	39	1	0	0	0	0	0	41
15 - 15.99	0	49	1	0	0	0	0	0	50
16 - 16.99	0	63	3	0	0	0	0	0	66
17 - 17.99	0	37	5	1	0	0	0	0	43
18 - 18.99	0	19	4	2	1	0	0	0	26
19 - 19.99	0	7	7	2	0	0	0	0	16
20 - 20.99	0	2	6	9	1	0	0	1	19
21 - 21.99	0	1	0	7	2	0	0	1	11
22 - 22.99	0	0	2	3	0	0	1	1	7
23 - 23.99	0	0	0	5	0	0	1	0	6
24 - 24.99	0	0	0	2	0	0	0	0	2
26 - 26.99	0	0	0	1	0	0	0	0	1
27 - 27.99	0	0	0	0	1	1	2	0	4
28 - 28.99	0	0	0	0	0	0	0	1	1
Totals	8	264	29	32	5	1	4	4	347

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for Spanish mackerel sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 0	1	2	3	4	5	6	7	N
7 - 7.99	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1
8 - 8.99	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	2
9 - 9.99	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1
11 - 11.99	0.6667	0.3333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	3
12 - 12.99	0.0667	0.9333	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	15
13 - 13.99	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	32
14 - 14.99	0.0244	0.9512	0.0244	0.0000	0.0000	0.0000	0.0000	0.0000	41
15 - 15.99	0.0000	0.9800	0.0200	0.0000	0.0000	0.0000	0.0000	0.0000	50
16 - 16.99	0.0000	0.9545	0.0455	0.0000	0.0000	0.0000	0.0000	0.0000	66
17 - 17.99	0.0000	0.8605	0.1163	0.0233	0.0000	0.0000	0.0000	0.0000	43
18 - 18.99	0.0000	0.7308	0.1538	0.0769	0.0385	0.0000	0.0000	0.0000	26
19 - 19.99	0.0000	0.4375	0.4375	0.1250	0.0000	0.0000	0.0000	0.0000	16
20 - 20.99	0.0000	0.1053	0.3158	0.4737	0.0526	0.0000	0.0000	0.0526	19
21 - 21.99	0.0000	0.0909	0.0000	0.6364	0.1818	0.0000	0.0000	0.0909	11
22 - 22.99	0.0000	0.0000	0.2857	0.4286	0.0000	0.0000	0.1429	0.1429	7
23 - 23.99	0.0000	0.0000	0.0000	0.8333	0.0000	0.0000	0.1667	0.0000	6
24 - 24.99	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	2
26 - 26.99	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	1
27 - 27.99	0.0000	0.0000	0.0000	0.0000	0.2500	0.2500	0.5000	0.0000	4
28 - 28.99	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	1
							Total Sampled		347

Chapter 8
Spot



Leiostomus xanthurus

INTRODUCTION

A total of 401 spot, *Leiostomus xanthurus*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. We were unable to age one fish due to the poor quality of its otoliths. The average age for the sample was 1.8 year old, and the standard deviation and standard error were 1.01 and 0.05, respectively. Seven age classes (0 to 6) were represented, comprising fish from the 1999-2005 year-classes, with fish predominantly from the 2004 year-class.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in labeled cell well trays.

Preparation — Otoliths were processed for ageing using a thin-sectioning technique. The first step in otolith preparation was to grind down the otolith in a transverse plane to its core using a Hillquist thin section machine's 320-mesh diamond cup wheel. To prevent distortion of the reading surface, the otolith was ground exactly perpendicular to the reading plane. The ground side of the otolith was then placed face down in a drop of Loctite 349 photo-active adhesive on a labeled glass slide and placed under ultraviolet light to allow the adhesive to harden. The Hillquist thin section machine's cup wheel was used again to grind the otolith, embedded in Loctite, to a thickness of 0.3 to 0.5 mm. Finally, a thin layer of Flo-texx mounting medium was applied to the otolith section to increase light transmission through the translucent zones, which provided enhanced contrast and greater readability.

Readings — Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 1).

All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the

Figure 1. Sectioned otolith from a 5 year old spot.

fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

The measurement of reader self-precision was high for both readers (Reader 1's CV = 0% and Reader 2's CV = 0.8%). Measurements of reader precision were high, with age disagreements for only 11 out of 400 fish aged and the average CV of 1.1%. Figure 2 illustrates the between readers' precision of age estimates. There was evidence of systematic disagreement between Reader 1 and Reader 2 (test of symmetry, $\chi^2 = 11$, df = 4, $P = 0.0266$).

Of the 400 fish aged with otoliths, 7 age classes were represented (Table 1). The average age for the sample was 1.8 year old, and the standard deviation and standard error were 1.01 and 0.05, respectively.

Year-class data (Figure 3) show that the fishery was comprised of 7 year-classes, with fish spawned in 2004 dominating the catch.

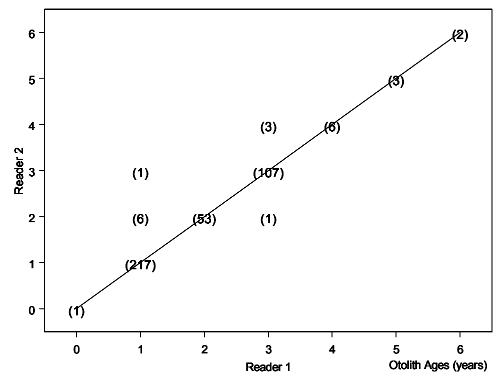


Figure 2. Between-reader comparison of otolith age estimates for spot.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

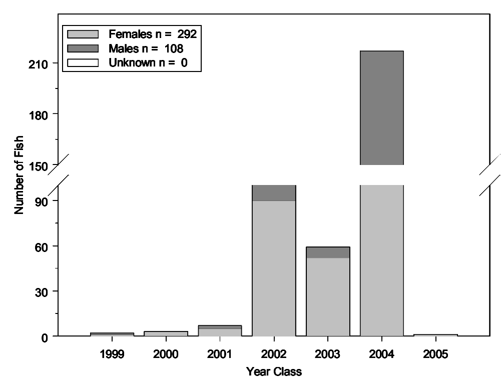


Figure 3. Year-class distribution for spot collected for ageing in 2005. Distribution is broken down by sex.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

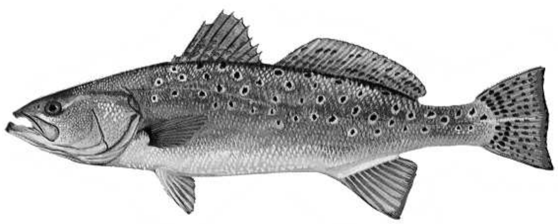
Table 1. The number of spot assigned to each total length-at-age category for 400 fish sampled for age determination in Virginia during 2005

Length	Age							
1-inch intervals	0	1	2	3	4	5	6	Totals
6 - 6.99	0	1	0	0	0	0	0	1
7 - 7.99	0	95	0	2	0	0	0	97
8 - 8.99	1	95	9	2	0	0	0	107
9 - 9.99	0	12	18	6	0	0	0	36
10 - 10.99	0	12	18	26	2	0	0	58
11 - 11.99	0	2	12	51	1	0	0	66
12 - 12.99	0	0	2	21	3	2	1	29
13 - 13.99	0	0	0	3	1	1	1	6
Totals	1	217	59	111	7	3	2	400

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-interval, based on otolith ages for spot sampled for age determination in Virginia during 2005

Length	Age							
1-inch intervals	0	1	2	3	4	5	6	N
6 - 6.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1
7 - 7.99	0.000	0.979	0.000	0.021	0.000	0.000	0.000	97
8 - 8.99	0.009	0.888	0.084	0.019	0.000	0.000	0.000	107
9 - 9.99	0.000	0.333	0.500	0.167	0.000	0.000	0.000	36
10 - 10.99	0.000	0.207	0.310	0.448	0.034	0.000	0.000	58
11 - 11.99	0.000	0.030	0.182	0.773	0.015	0.000	0.000	66
12 - 12.99	0.000	0.000	0.069	0.724	0.103	0.069	0.034	29
13 - 13.99	0.000	0.000	0.000	0.500	0.167	0.167	0.167	6
						Sample Size		400

Chapter 9
Spotted Seatrout



Cynoscion nebulosus

INTRODUCTION

A total of 212 spotted seatrout, *Cynoscion nebulosus*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. The average age for the sample was 1.0 years old, and the standard deviation and standard error were 0.54 and 0.04, respectively. Five age classes (0 to 3, and 6) were represented, comprising fish from the 1999, 2002-2005 year-classes, with fish primarily from the 2004 year-class.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. They were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and each fish assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in labeled cell well trays.

Preparation — The first step in seatrout otolith preparation was to make a transverse cut just off center of the otolith with a Hillquist thin section machine's cut-off saw equipped with an HCR-100 diamond blade. To prevent distortion of the reading surface, the cut surface of the otolith half containing the focus was ground down on a Hillquist thin section machine's 320 mesh diamond cup wheel until perpendicular to the reading plane. The otolith's ground surface was then placed face down in a drop of Loctite 349 photo-active adhesive on a labeled glass slide and placed under ultraviolet light to allow the adhesive to harden (approximately ten minutes). The Hillquist thin section machine's cup wheel was used again to grind the otolith, embedded in Loctite, to a thickness of 0.3 to 0.5 mm. Finally, a thin layer of Flo-texx mounting medium was applied to the otolith section to increase light transmission through the translucent zones, which provided enhanced contrast and greater readability.

Readings — Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 1). All

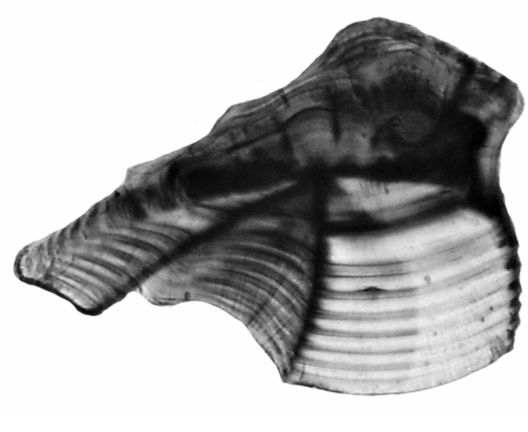


Figure 1. Sectioned otolith from an 8 year old male spotted seatrout.

samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

No bias was discovered in any of the self-precision tests of otolith age estimates, with both readers equally able to reproduce the ages of previously read samples (Both readers had 0% CVs). There was also 100 percent agreement between reader age estimates. Figure 2 illustrates the between readers' precision of age estimates.

Of the 212 fish aged with otoliths, 5 age classes were represented (Table 1). The average age for the sample was 1.0 years old, and the standard deviation and standard error were 0.54 and 0.04, respectively.

Year-class data (Figure 3) show that the fishery was comprised of 5 year-classes, comprising fish from the 1999, 2002-2005 year-classes, with fish primarily from the 2004 year-class.

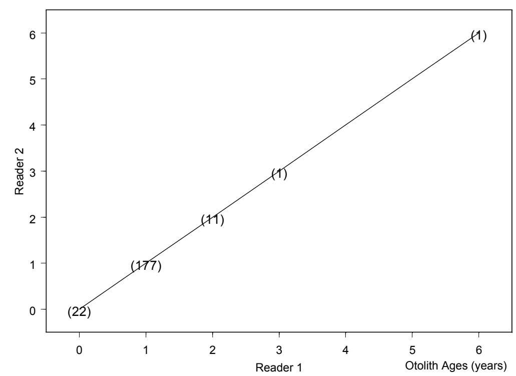


Figure 2. Between-reader comparison of otolith age estimates for spotted seatrout.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

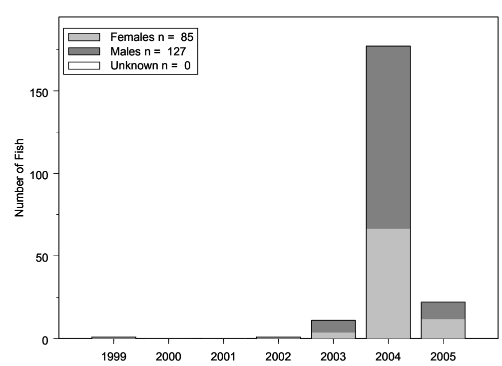


Figure 3. Year-class distribution for spotted seatrout collected for ageing in 2005. Distribution is broken down by sex.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

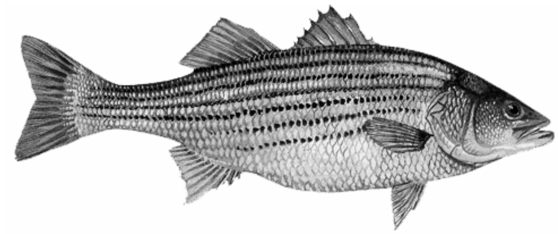
Table 1. The number of spotted seatrout assigned to each total length-at-age category for 212 fish sampled for age determination in Virginia during 2005 (no length for 2 fish).

Length 1-inch intervals	Age (years) 0	1	2	3	6	Totals
8 - 8.99	2	0	0	0	0	2
9 - 9.99	1	0	0	0	0	1
10 - 10.99	2	1	0	0	0	3
11 - 11.99	4	0	0	0	0	4
12 - 12.99	8	3	0	0	0	11
13 - 13.99	3	0	0	0	0	3
14 - 14.99	0	3	0	0	0	3
15 - 15.99	0	14	0	0	0	14
16 - 16.99	1	48	0	0	0	49
17 - 17.99	1	51	2	0	0	54
18 - 18.99	0	30	3	0	0	33
19 - 19.99	0	20	2	0	0	22
20 - 20.99	0	5	4	0	0	9
25 - 25.99	0	0	0	1	0	1
30 - 30.99	0	0	0	0	1	1
Totals	22	175	11	1	1	210

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for spotted seatrout sampled for age determination in Virginia during 2005 (no length for 2 fish).

Length 1-inch intervals	Age (years) 0	1	2	3	6	N
8 - 8.99	1.000	0.000	0.000	0.000	0.000	2
9 - 9.99	1.000	0.000	0.000	0.000	0.000	1
10 - 10.99	0.667	0.333	0.000	0.000	0.000	3
11 - 11.99	1.000	0.000	0.000	0.000	0.000	4
12 - 12.99	0.727	0.273	0.000	0.000	0.000	11
13 - 13.99	1.000	0.000	0.000	0.000	0.000	3
14 - 14.99	0.000	1.000	0.000	0.000	0.000	3
15 - 15.99	0.000	1.000	0.000	0.000	0.000	14
16 - 16.99	0.020	0.980	0.000	0.000	0.000	49
17 - 17.99	0.019	0.944	0.037	0.000	0.000	54
18 - 18.99	0.000	0.909	0.091	0.000	0.000	33
19 - 19.99	0.000	0.909	0.091	0.000	0.000	22
20 - 20.99	0.000	0.556	0.444	0.000	0.000	9
25 - 25.99	0.000	0.000	0.000	1.000	0.000	1
30 - 30.99	0.000	0.000	0.000	0.000	1.000	1
					Sample Size	210

Chapter 10
Striped Bass



Morone saxatilis

INTRODUCTION

A total of 1396 striped bass, *Morone saxatilis*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. For 332 fish both otoliths and scales were taken from the same specimen; for 1063 additional fish only scales were taken from each specimen; for one fish only otoliths were taken. We were unable to age 14 fish due to the quality of either their scales or otoliths. The average scale age was 9.5 years, with 16 age classes (3 to 18) comprising fish from the 1987 to 2002 year-classes. The average otolith age was 8.0 years, with 17 age classes (3 to 18 and 23) comprising fish from the 1982, and 1987 to 2002 year-classes.

METHODS

Handling of collection — Otoliths and scales were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and each fish assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in labeled cell well plates, while scales were stored in their original coin envelopes.

Preparation —

Scales – Striped bass scales were prepared for age and growth analysis by making acetate impressions of the scale microstructure. Due to extreme variation in the size and shape of scales from individual fish, we selected only those scales that had even margins and which were of uniform size. We selected a range of four to six preferred scales (based on overall scale size) from each fish, making sure that only non-regenerated scales were used. Scale impressions were made on extruded clear 020 acetate sheets (25 mm x 75 mm) with a Carver Laboratory Heated Press (model "C"). The scales were pressed with the following settings:

Pressure:	15000 psi
Temperature:	77°C (170°F)
Time:	5 to 10 min

Striped bass scales that were the size of a quarter (coin) or larger, were pressed individually for up to twenty minutes. After pressing, the impressions were viewed with a Bell and Howell microfiche reader and checked again for regeneration and incomplete margins. Impressions that were too light, or when all scales were regenerated a new impression was made using different scales from the same fish.

Otoliths — We used a thin-section and bake technique to process striped bass otoliths for age determination. Otolith preparation began by randomly selecting either the right or left otolith. The otolith was mounted with Crystal Bond onto a standard microscope slide with its distal surface orientated upwards. Once mounted, a small mark was placed on the otolith surface directly above the otolith focus. The slide, with attached otolith, was then secured to an Isomet saw equipped with two diamond wafering blades separated by a 0.5 mm spacer, which was slightly smaller in diameter than the diamond blades. The otolith was positioned so that the wafering blades straddled each side of the otolith focus ink mark. It was crucial that this cut be perpendicular to the long axis of the otolith. Failure to do so resulted in "broadening" and distortion of winter growth zones. A proper cut resulted in annuli that were clearly defined and delineated. Once cut, the otolith section was placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400°C. Baking time was otolith size dependent and gauged by color, with a light caramel color desired. Once a suitable color was reached the baked thin-section was placed on a labeled glass slide and covered with a thin layer of Flo-texx mounting medium, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — By convention, a birthdate of January 1 is assigned to all Northern Hemisphere fish species. We use a system of age determination that assigns age class according to the date of sacrifice with respect to this international accepted birthdate and the timing of annulus formation, which occurs between the months of May and June for striped bass. Once the reader decides how many annuli are visible on the ageing structure, the year class is assigned. The year class designation, or age, is written first followed by the actual number of annuli visible listed within brackets (e.g. 3(3)). The presence of a "+" after the number in the brackets indicates new growth, or "plus growth" visible on the structure's margin. Using this method, a fish sacrificed in January before annulus formation with three visible annuli would be assigned the same age, 4(3+), as a fish with four visible annuli sacrificed in July after annulus formation, 4(4).

Two different readers aged all samples in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the age readers were unable to agree on a final age, the fish was excluded from further analysis.

Scales - We determined fish age by viewing acetate impressions of scales (Figure 1) with a standard Bell and Howell R-735 microfiche reader equipped with 20 and 29 mm lenses.

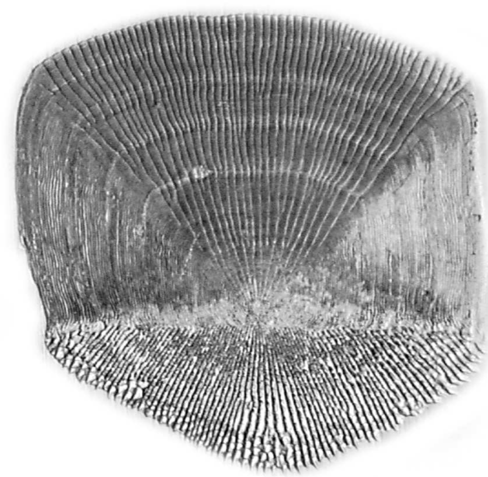


Figure 1. Scale impression of a 5-year-old male striped bass.

Annuli on striped bass scales are identified based on two scale microstructure features, "crossing over" and circuli disruption. Primarily, "crossing over" in the lateral margins near the posterior\anterior interface of the scale is used to determine the origin of the annulus. Here compressed circuli (annulus) "cross over" the previously deposited circuli of the previous year's growth. Typically annuli of the first three years can be observed transversing this interface as dark bands. These bands remain consistent throughout the posterior field and rejoin the posterior\anterior interface on the opposite side of the focus. Annuli can also be observed in the anterior lateral field of the scale. Here the annuli typically reveal a pattern of discontinuous and suddenly breaking segmented circuli. This event can also be distinguished by the presence of concentric white lines, which are typically associated with the disruption of circuli.

Annuli can also be observed bisecting the perpendicular plain of the radial striations in the anterior field of the scale. Radii emanate out from the focus of the scale towards the outer corner margins of the anterior field. These radial striations consist mainly of segmented concave circuli. The point of intersection between radii and annuli results in a "straightening out" of the concave circuli. This straightening of the circuli should be consistent throughout the entire anterior field of the scale. This event is further amplified by the presence of concave circuli neighboring both directly above and below the annulus.

The first year's annulus can be difficult to locate on some scales. It is typically best identified in the lateral field of the anterior portion of the scale. The distance from the focus to the first year's annulus is typically larger with respect to the following few annuli. For the annuli two through six, summer growth generally decreases proportionally. For ages greater than six, a crowding effect of the annuli near the outer margins of the scale is observed. This crowding effect creates difficulties in edge interpretation. At this point it is best to focus on the straightening of the circuli at the anterior margins of the scale.

When ageing young striped bass, zero through age two, extreme caution must be taken as not to over age the structure. In young fish there is no point of reference to aid in the determination of the first year; this invariably results in over examination of the scale and such events as hatching or saltwater incursion marks (checks) may be interpreted as the first year.

Otoliths – Sectioned otoliths were aged by two different readers using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 2).

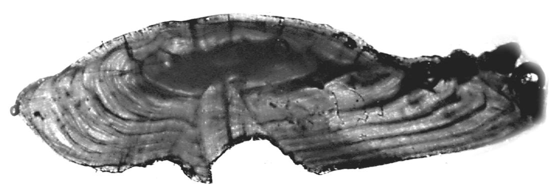


Figure 2. Otolith thin-section of a 5-year-old male striped bass.

By convention an annulus is identified as the narrow opaque zone, or winter growth. Typically the first year's annulus can be determined by first locating the focus of the otolith. The focus is generally located, depending on preparation, in the center of the otolith, and is visually well defined as a dark oblong region. The first year's annulus can be located directly below the focus, along the outer ridge of the sulcal groove on the ventral and dorsal sides of the otolith. This insertion point along the sulcal ridge resembles a check mark (not to be confused with a false annulus). Here the annulus can be followed outwards along the ventral and dorsal surfaces where it encircles the focus. Subsequent annuli also emanate from the sulcal ridge, however, they do not encircle the focus, but rather travel outwards to the distal surface of the otolith. To be considered a true annulus, each annulus must be rooted in the sulcus and travel without interruption to the distal surface of the otolith. The annuli in striped bass have a tendency to split as they advance towards the distal surface. As a result, it is critical that reading path proceed in a direction down the sulcal ridge and outwards to the distal surface.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 60 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

Scales — Measurements of reader self-precision was marginal; with both readers able to reproduce the ages of previously read scales (Reader 1's CV = 9.6% and Reader 2's CV = 5.3%). In Figure 3 we present a graph of the results for between-reader scale ageing precision. The between-reader agreement for scale for one year or less was 76.6% of all aged fish. The average between-reader coefficient of variation (CV) of 7.4% was marginal. There was evidence of systematic disagreement between Reader 1 and Reader 2

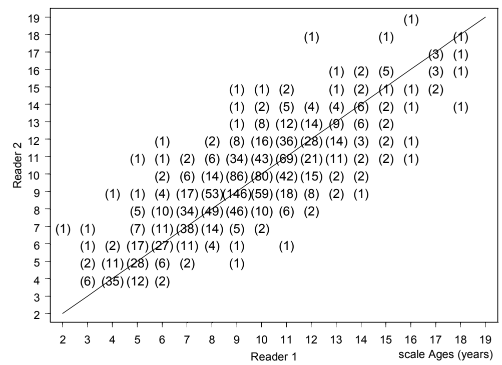


Figure 3. Between-reader comparison of scale age estimates for striped bass.

(test of symmetry, $\chi^2 = 94.5$, df = 61, P = 0.0038).
Of the 1382 striped bass aged with scales, 16 age classes (3 to 18) were represented. The average age for the sample was 9.5 years. The standard deviation and standard error were 2.58 and 0.07, respectively.

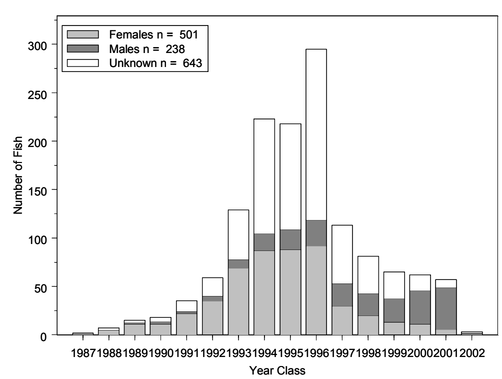


Figure 4. Year-class frequency distribution for striped bass collected for ageing in 2005. Distribution of scale ages is broken down by sex.

Year-class data (Figure 4) indicates that recruitment into the fishery typically begins at age 3, which corresponds to the 2002 year-class for striped bass caught in 2005. Striped bass appear to fully recruit to the fishery at age 9 (1996 year-class).

Otoliths — There was good between-reader agreement for otolith age readings using sectioned otoliths, with age differences between the two readers one year or less for 97.6% of all aged fish (Figure 5). The between reader average CV for otolith age estimates was only 2.1%, very comparable to the CV of 1.7% reported for 2004 fish. Unlike scale ages, there was no evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 20.4$, df = 18, P = 0.3126).

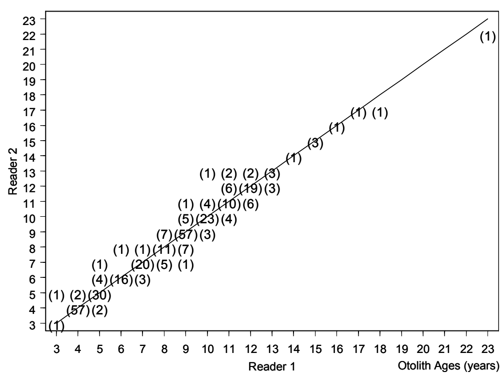


Figure 5. Between-reader comparison of otolith age estimates for striped bass.

Measurements of reader self-precision were high, with both readers able to reproduce the ages of previously read otoliths (Reader 1's CV = 1.9% and Reader 2's CV = 1.7%). Of 327 fish aged with otoliths, 17 age classes (3 to 18, and 23) were represented for striped bass aged with otoliths. The average age for the sample was 8.0 years. The standard deviation and standard error were 3.08 and 0.17, respectively.

Comparison of Scale and Otolith Ages — While the CV of otolith and scales age estimates was 8.4%, there was no evidence of systematic disagreement between otolith and scale ages (test of symmetry, $\chi^2 = 49.7$, df = 39, $P = 0.1177$). Scales were assigned a lower age than otoliths for 30% of the fish and 27% of the time were scales assigned a higher age than otoliths (Figure 6). There was also evidence of bias between otolith and scale ages using an age bias plot (Figure 7), again with scales generally assigned higher ages for younger fish and lower ages for older fish than otoliths age estimates.

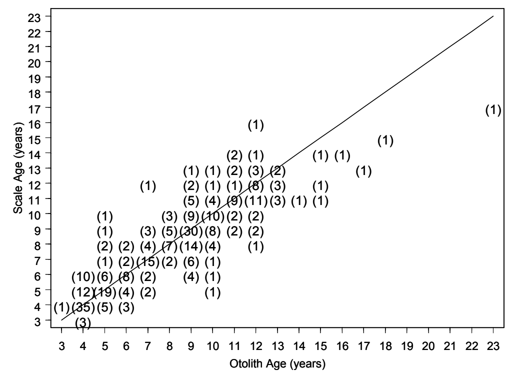


Figure 6. Comparison of otolith and scale age estimates for striped bass.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using scale ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

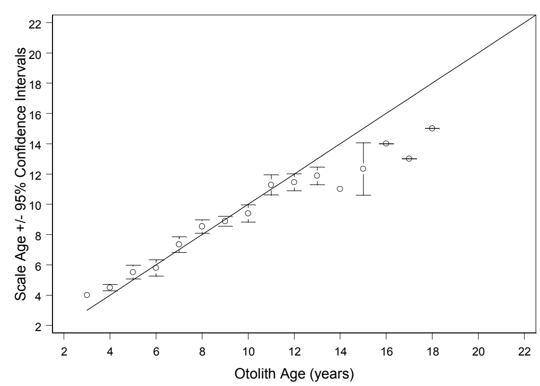


Figure 7. Age-bias plot for striped bass scale and otolith age estimates.

RECOMMENDATIONS

•We recommend that VMRC and ASMFC use otoliths for ageing striped bass. Although preparation time is greater for otoliths compared to scales, nonetheless as the mean age of striped bass increases in the recovering fishery, otoliths should provide more reliable estimates of age. We will continue to compare the age estimates between otoliths and scales.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-PLUS. 1999. Guide to Statistics, Vol 1. Data Analysis and Products Division. MathSoft, Inc. Seattle, Washington.

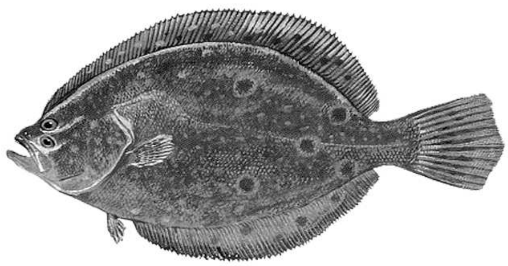
Table 1. The number of striped bass assigned to each total length-at-age category for 1382 fish collected for age determination in Virginia during 2005 (length not determined for 4 fis

Length 1-inch intervals	Age (years) 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	Totals
18 - 18.99	0	7	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8
19 - 19.99	2	11	5	1	0	0	0	0	0	0	0	0	0	0	0	0	19
20 - 20.99	0	11	3	3	4	0	0	0	0	0	0	0	0	0	0	0	21
21 - 21.99	0	7	16	9	1	0	0	0	0	0	0	0	0	0	0	0	33
22 - 22.99	0	7	5	5	4	3	1	1	0	0	0	0	0	0	0	0	26
23 - 23.99	1	5	11	7	4	1	1	1	0	0	0	0	0	0	0	0	31
24 - 24.99	0	6	9	8	8	4	0	0	1	0	0	0	0	0	0	0	36
25 - 25.99	0	2	3	7	8	8	2	1	0	0	0	0	0	0	0	0	31
26 - 26.99	0	0	2	4	4	8	3	4	0	0	0	0	0	0	0	0	25
27 - 27.99	0	0	2	8	7	8	9	5	2	0	0	0	0	0	0	0	41
28 - 28.99	0	1	4	3	9	3	9	2	5	1	0	0	0	0	0	0	37
29 - 29.99	0	0	1	6	3	8	12	4	4	0	1	0	0	0	0	0	39
30 - 30.99	0	0	0	0	7	8	10	7	3	2	0	0	0	0	0	0	37
31 - 31.99	0	0	0	1	7	10	16	11	5	4	3	1	1	0	0	0	59
32 - 32.99	0	0	0	1	6	13	28	9	13	4	2	1	1	0	0	0	78
33 - 33.99	0	0	0	1	3	10	32	20	14	1	5	3	0	0	0	0	89
34 - 34.99	0	0	0	1	1	14	39	23	21	10	5	1	1	1	0	0	117
35 - 35.99	0	0	0	0	2	12	37	25	22	11	4	1	0	1	0	0	115
36 - 36.99	0	0	0	0	2	3	41	37	40	13	5	3	1	2	1	0	148
37 - 37.99	0	0	0	0	1	0	40	37	35	36	11	1	0	0	0	0	161
38 - 38.99	0	0	0	0	0	0	10	9	17	11	8	1	1	1	0	0	58
39 - 39.99	0	0	0	0	0	0	3	10	16	8	6	3	2	0	1	0	49
40 - 40.99	0	0	0	0	0	0	1	8	10	11	3	1	3	4	0	1	42
41 - 41.99	0	0	0	0	0	0	0	2	7	3	0	4	1	0	0	0	17
42 - 42.99	0	0	0	0	0	0	1	0	4	5	1	6	1	1	0	0	19
43 - 43.99	0	0	0	0	0	0	0	0	1	5	2	2	2	1	1	0	14
44 - 44.99	0	0	0	0	0	0	0	1	0	3	2	3	2	1	0	0	12
45 - 45.99	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	4
46 - 46.99	0	0	0	0	0	0	0	0	0	0	0	3	1	0	1	1	6
47 - 47.99	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
48 - 48.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
49 - 49.99	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	2
52 - 52.99	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Totals	3	57	62	65	81	113	295	217	220	129	59	35	18	15	7	2	1378

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on scale ages for striped bass sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	N
18 - 18.99	0.00	0.88	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8
19 - 19.99	0.11	0.58	0.26	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19
20 - 20.99	0.00	0.52	0.14	0.14	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21
21 - 21.99	0.00	0.21	0.48	0.27	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33
22 - 22.99	0.00	0.27	0.19	0.19	0.15	0.12	0.04	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	26
23 - 23.99	0.03	0.16	0.35	0.23	0.13	0.03	0.03	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
24 - 24.99	0.00	0.17	0.25	0.22	0.22	0.11	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	36
25 - 25.99	0.00	0.06	0.10	0.23	0.26	0.26	0.06	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31
26 - 26.99	0.00	0.00	0.08	0.16	0.16	0.32	0.12	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	25
27 - 27.99	0.00	0.00	0.05	0.20	0.17	0.20	0.22	0.12	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41
28 - 28.99	0.00	0.03	0.11	0.08	0.24	0.08	0.24	0.05	0.14	0.03	0.00	0.00	0.00	0.00	0.00	0.00	37
29 - 29.99	0.00	0.00	0.03	0.15	0.08	0.21	0.31	0.10	0.10	0.00	0.03	0.00	0.00	0.00	0.00	0.00	39
30 - 30.99	0.00	0.00	0.00	0.00	0.19	0.22	0.27	0.19	0.08	0.05	0.00	0.00	0.00	0.00	0.00	0.00	37
31 - 31.99	0.00	0.00	0.00	0.02	0.12	0.17	0.27	0.19	0.08	0.07	0.05	0.02	0.02	0.00	0.00	0.00	59
32 - 32.99	0.00	0.00	0.00	0.01	0.08	0.17	0.36	0.12	0.17	0.05	0.03	0.01	0.01	0.00	0.00	0.00	78
33 - 33.99	0.00	0.00	0.00	0.01	0.03	0.11	0.36	0.22	0.16	0.01	0.06	0.03	0.00	0.00	0.00	0.00	89
34 - 34.99	0.00	0.00	0.00	0.01	0.01	0.12	0.33	0.20	0.18	0.09	0.04	0.01	0.01	0.01	0.00	0.00	117
35 - 35.99	0.00	0.00	0.00	0.00	0.02	0.10	0.32	0.22	0.19	0.10	0.03	0.01	0.00	0.01	0.00	0.00	115
36 - 36.99	0.00	0.00	0.00	0.00	0.01	0.02	0.28	0.25	0.27	0.09	0.03	0.02	0.01	0.01	0.01	0.00	148
37 - 37.99	0.00	0.00	0.00	0.00	0.01	0.00	0.25	0.23	0.22	0.22	0.07	0.01	0.00	0.00	0.00	0.00	161
38 - 38.99	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.16	0.29	0.19	0.14	0.02	0.02	0.02	0.00	0.00	58
39 - 39.99	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.20	0.33	0.16	0.12	0.06	0.04	0.00	0.02	0.00	49
40 - 40.99	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.19	0.24	0.26	0.07	0.02	0.07	0.10	0.00	0.02	42
41 - 41.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.41	0.18	0.00	0.24	0.06	0.00	0.00	0.00	17
42 - 42.99	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.21	0.26	0.05	0.32	0.05	0.05	0.00	0.00	19
43 - 43.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.36	0.14	0.14	0.14	0.07	0.07	0.00	14
44 - 44.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.25	0.17	0.25	0.17	0.08	0.00	0.00	12
45 - 45.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.25	0.00	0.50	0.00	0.00	4
46 - 46.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.17	0.00	0.17	0.17	6
47 - 47.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	1
48 - 48.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	2
49 - 49.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.50	0.00	0.00	0.00	2
52 - 52.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1
														Sample size			1378

Chapter 11
Summer Flounder



Paralichthys dentatus

INTRODUCTION

A total of 362 summer flounder, *Paralichthys dentatus*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. For 356 fish both scales and otoliths were collected from the same specimen; for 4 fish only otoliths were collected from each specimen; for 2 fish only scales were collected from each specimen. We were unable to age 4 fish due to the quality of their scales and 15 fish due to the quality of their otoliths. The average scale age was 2.5 years, representing 10 year-classes (1996 to 2005). Fish from the 2002-2004 year-classes dominated the collection. The average otolith age was 2.5 years, representing 10 year-classes (1994, 1996 to 2004).

METHODS

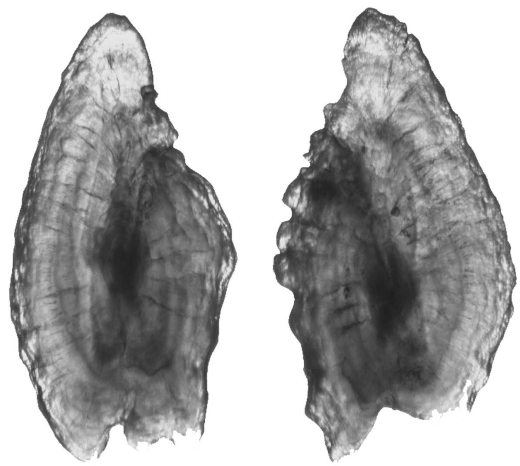
Handling of collection — Otoliths and scales were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and each fish assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in labeled cell well plates, while scales were stored in their original coin envelopes.

Preparation —

Scales – Summer flounder scales were prepared for age and growth analysis by making acetate impressions of the scale microstructure. Due to extreme variation in the size and shape of scales from individual fish, we selected only those scales that had even margins and uniform size. We selected a range of five to ten preferred scales (based on overall scale size) from each fish, making sure that only non-regenerated scales were used. Scale impressions were made on extruded clear 020 acetate sheets (25 mm x 75 mm) with a Carver Laboratory Heated Press (model "C"). The scales were pressed with the following settings:

Pressure:	12000 to 15000 psi
Temperature:	Room temperature
Time:	7 minutes

Otoliths – The left otoliths of summer flounder are symmetrical in relation to the otolith nucleus, while right otoliths are asymmetrical (Figure 1). The right sagittal otolith was mounted with Aremco's clear Crystal Bond^{TM} 509 adhesive onto a standard microscope slide with its distal surface orientated upwards. Once mounted, a small mark was placed on the otolith surface directly above the otolith focus. The slide, with attached otolith, was then secured to a Buehler Isomet saw equipped with two Norton diamond wafering blades separated by a 0.5 mm stainless steel spacer, which was slightly smaller in diameter than the diamond blades. The otolith was positioned so that the wafering blades straddled each side of the otolith focus ink mark. It was crucial that this cut be perpendicular to the long axis of the otolith. Failure to do so



(a) (b)

Figure 1. Whole otoliths from a 485 mm (total length) female summer flounder. (a) left otolith (b) right otolith.

resulted in "broadening" and distortion of winter growth zones. A proper cut resulted in annuli that were clearly defined and delineated. Once cut, the otolith section was placed into a ceramic "Coors" spot plate well and baked in a Thermolyne 1400 furnace at 400°C. Baking time was otolith size dependent and gauged by color, with a light caramel color desired. Once a suitable color was reached the baked thin-section was placed on a labeled glass slide and covered with a thin layer of Flo-texx mounting medium, which provided enhanced contrast and greater readability by increasing light transmission through the sections.

Readings — By convention, a birthdate of January 1 is assigned to all Northern Hemisphere fish species. The Age and Growth Lab uses a system of age determination that assigns age class according to the date of sacrifice with respect to this international accepted birthdate and the timing of annulus formation, which occurs in Virginia's waters between the months of February and April. Using this method, a fish sacrificed in January before annulus formation with three visible annuli will be assigned the same age as a fish with four visible annuli sacrificed in July after annulus formation. Once the reader has decided how many annuli are visible on the ageing structure, the year class is assigned. The year class designation, or age, is written first followed by the actual number of annuli visible listed within brackets (e.g. 3(3)). The presence of a "+" after the number in the brackets indicates new growth, or "plus growth" visible on the structure's margin.

Two different readers aged all samples in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Scales - We determined fish age by viewing the acetate impressions of scales (Figure 2) with a standard Bell and Howell R-735 microfiche reader equipped with 20 and 29 mm lenses.

Annuli on summer flounder scales are primarily identified by the presence of crossing over of circuli. Crossing over is most evident on the lateral margins near the posterior/anterior interface of the scale. Here compressed circuli (annulus) "cross over" the deposited circuli of the previous year's growth. Typically the annulus will protrude partially into the ctenii of the posterior field, but not always.

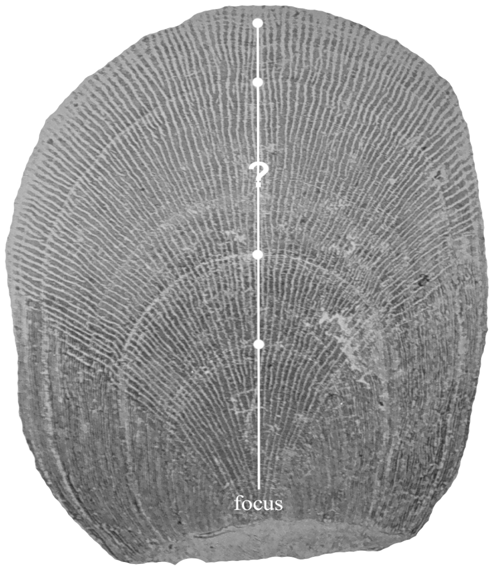


Figure 2. Scale impression of a 590 mm female summer flounder collected in November and aged as 4-years-old with scales. The question mark is located at a possible "3rd" annulus.

Following the annulus up into the anterior field of the scale reveals a pattern of discontinuous and suddenly breaking segmented circuli. This event can also be distinguished by the presence of concentric white lines, which are associated with the disruption of circuli. This pattern should be continuous throughout the entire anterior field of the scale. Locating the first annulus can be difficult due to latitudinal differences in growth rates and changes in the size of the first annulus due to a protracted spawning season. We consider the first annulus to be the first continuous crossing over event formed on the scale.

Otoliths – Sectioned otoliths were aged by two different readers using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 3).

Summer flounder otoliths are composed of visually distinct summer and winter growth zones. By convention, an annulus is identified as the narrow opaque zone, or winter growth band. With sectioned otoliths, to be considered a true annulus, these growth bands must be rooted in the sulcus and able to be followed, without interruption to the distal surface of the otolith. The annuli in summer flounder have a tendency to split as they advance towards the distal surface. As a result, it is critical that the reading path proceeds in a direction from the sulcus to the proximal surface. The first annulus is located directly below the focus and near the upper portion of the sulcal groove. The distance from the focus to the first year is moderate, with translucent zone deposition gradually becoming smaller as consecutive annuli are deposited towards the outer edge.

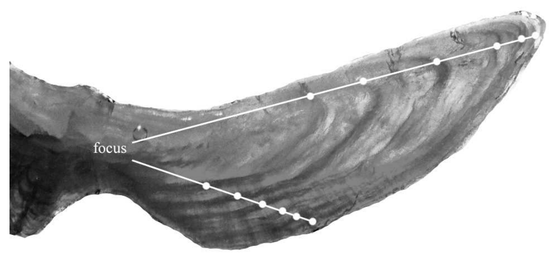


Figure 3. Otolith section from a 590 mm, 6-year-old female summer flounder collected in November. Same fish as Figure 2.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

Scales — Measurements of reader self-precision was fair for Read 1 (Reader 1's CV = 4.2% and Reader 2's CV = 13.4%). There was evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 51.3$, df = 12, $P < 0.0001$). In Figure 4 we present a graph of the results for between-reader scale ageing precision. The average between-reader coefficient of variation (CV) of 9.2% was relatively high. The between-reader agreement for scale for one year or less was 97.5% of all aged fish. Such a high agreement between the readers and the high CV for Read 2 were partially due to the sample dominated by younger fish.

Of the 358 fish aged with scales, 10 age-classes (0 to 9) were represented (Table 1). The average scale age was 2.5 years, and the standard deviation and standard error were 1.43 and 0.08, respectively.

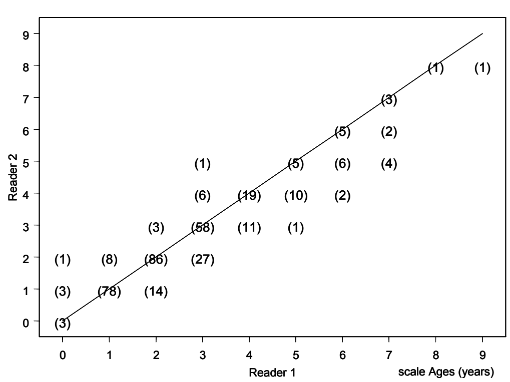


Figure 4. Between-reader comparison of scale age estimates for summer flounder.

Year-class data (Figure 5) indicate that recruitment into the fishery began at age 0, which corresponds to the 2005 year-class for summer flounder caught in 2005. Year-class abundance was high for the 2002–2004 year-classes, but declined sharply in the 2001 year-class and remained low for the earlier years.

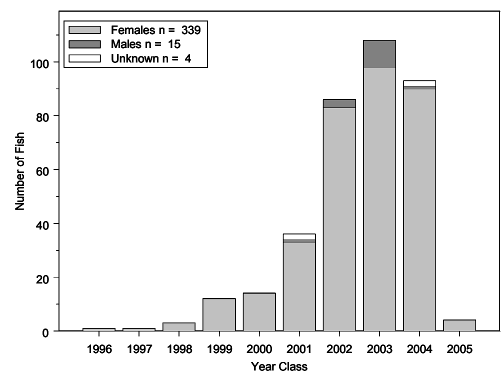


Figure 5. Scale year-class distribution for summer flounder collected in 2005. Distribution is broken down by sex.

Otoliths — Measurements of reader self-precision were high, with both readers able to reproduce the ages of previously read otoliths (Reader 1's CV = 4.9% and Reader 2's CV = 0.6%). There was no evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 8.9$, df = 7, P = 0.2621). In Figure 6 we present a

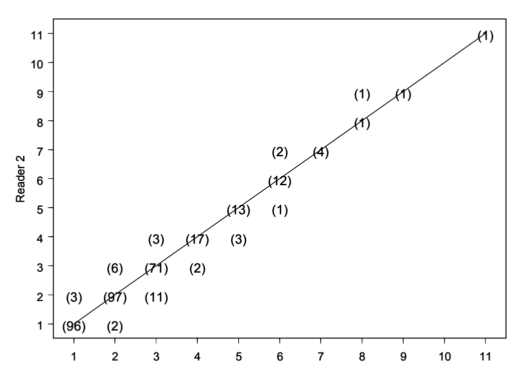


Figure 6. Between-reader comparison of otolith age estimates for summer flounder.

graph of the results for between-reader otolith ageing precision. The average between-reader coefficient of variation (CV) of 2.6% was not significant.

Of the 347 fish aged with otoliths, 10 age-classes (1 to 9, and 11) were represented. The average age for the sample was 2.5 years. The standard deviation and standard error were 1.57 and 0.09, respectively.

Comparison of Scale and Otolith Ages — Otolith and scales ages were similar, with an average CV of 9.3% for the 347 fish for which both otoliths and scales were aged. Although statistically there was no evidence of systematic disagreement between otolith and scale ages (test of symmetry, $\chi^2 = 22.5$, df = 14, P = 0.0699), signs of under-aging occurred and could be important when older year classes might be present. In Figure 7 we present a graph of the results for between-reader otolith/scale ageing precision. There was some evidence of bias between otolith and scale ages for the oldest fish in the sample (Figure 8), but this could be due to the extremely small number of fish in these age categories.

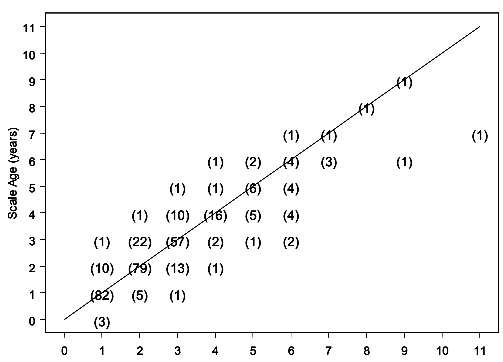


Figure 7. Comparison of otolith and scale age estimates for summer flounder.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using scale ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

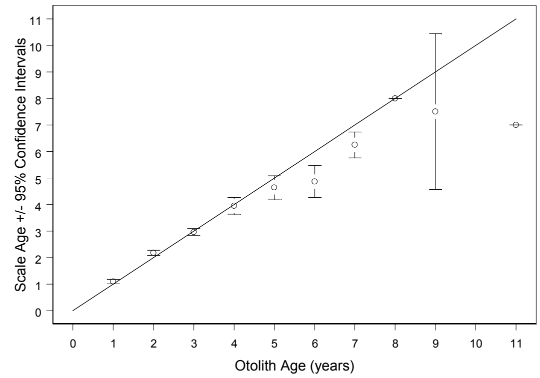


Figure 8. Age-bias plot for summer flounder scale and otolith age estimates.

REFERENCES

Bolz, G., R. Monaghan, K. Lang, R. Gregory, and J. Burnett. 1999. Proceedings of the summer flounder ageing workshop, 1-2 February 1999, Woods Hole, MA. . NOAA Tech. Memo, in press.

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

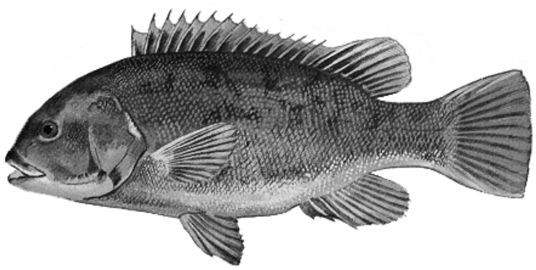
Table 1. The number of summer flounder assigned to each total length-at-age category for 358 fish sampled for age determination in Virginia during 2005.

Length	Age (years)										
1-inch intervals	0	1	2	3	4	5	6	7	8	9	Totals
11 - 11.99	0	1	0	0	0	0	0	0	0	0	1
13 - 13.99	1	4	1	0	0	0	0	0	0	0	6
14 - 14.99	3	47	22	7	0	0	0	0	0	0	79
15 - 15.99	0	29	23	7	0	0	0	0	0	0	59
16 - 16.99	0	10	31	18	3	0	0	0	0	0	62
17 - 17.99	0	2	17	23	4	0	0	0	0	0	46
18 - 18.99	0	0	9	12	4	0	0	0	0	0	25
19 - 19.99	0	0	3	13	8	0	0	0	0	0	24
20 - 20.99	0	0	2	3	7	2	0	0	0	0	14
21 - 21.99	0	0	0	2	3	3	0	0	0	0	8
22 - 22.99	0	0	0	0	4	3	3	1	0	1	12
23 - 23.99	0	0	0	1	3	4	3	0	0	0	11
24 - 24.99	0	0	0	0	0	1	3	1	0	0	5
25 - 25.99	0	0	0	0	0	1	2	1	0	0	4
27 - 27.99	0	0	0	0	0	0	1	0	0	0	1
28 - 28.99	0	0	0	0	0	0	0	0	1	0	1
Totals	4	93	108	86	36	14	12	3	1	1	358

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on scale ages for summer flounder sampled for age determination in Virginia during 2005.

Length	Age (years)										
1-inch intervals	0	1	2	3	4	5	6	7	8	9	N
11 - 11.99	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1
13 - 13.99	0.167	0.667	0.167	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6
14 - 14.99	0.038	0.595	0.278	0.089	0.000	0.000	0.000	0.000	0.000	0.000	79
15 - 15.99	0.000	0.492	0.390	0.119	0.000	0.000	0.000	0.000	0.000	0.000	59
16 - 16.99	0.000	0.161	0.500	0.290	0.048	0.000	0.000	0.000	0.000	0.000	62
17 - 17.99	0.000	0.043	0.370	0.500	0.087	0.000	0.000	0.000	0.000	0.000	46
18 - 18.99	0.000	0.000	0.360	0.480	0.160	0.000	0.000	0.000	0.000	0.000	25
19 - 19.99	0.000	0.000	0.125	0.542	0.333	0.000	0.000	0.000	0.000	0.000	24
20 - 20.99	0.000	0.000	0.143	0.214	0.500	0.143	0.000	0.000	0.000	0.000	14
21 - 21.99	0.000	0.000	0.000	0.250	0.375	0.375	0.000	0.000	0.000	0.000	8
22 - 22.99	0.000	0.000	0.000	0.000	0.333	0.250	0.250	0.083	0.000	0.083	12
23 - 23.99	0.000	0.000	0.000	0.091	0.273	0.364	0.273	0.000	0.000	0.000	11
24 - 24.99	0.000	0.000	0.000	0.000	0.000	0.200	0.600	0.200	0.000	0.000	5
25 - 25.99	0.000	0.000	0.000	0.000	0.000	0.250	0.500	0.250	0.000	0.000	4
27 - 27.99	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	1
28 - 28.99	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	1
									Sample Size		358

Chapter 12
Tautog



Tautoga onitis

INTRODUCTION

A total of 518 tautog, *Tautoga onitis*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. Otoliths were not collected from 1 fish, leaving 517 fish for which both otoliths and opercula were collected. Our results and analyses are based on operculum ages, unless otherwise noted, to allow our data to be directly comparable to other tautog age and growth studies. We were unable to age 2 fish due to the quality of their opercula, and 13 fish due to the quality of their otoliths. The average operculum age for the sample was 4.1 years, and the standard deviation and standard error were 2.20 and 0.09, respectively. Sixteen age-classes (1-16) were represented, comprising fish from the 1989 through 2004 year-classes.

METHODS

Handling of collection — Otoliths and opercula were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and each fish assigned a unique Age and Growth Laboratory sample number. All otoliths were stored dry in labeled cell well plates, while opercula were stored frozen in their original coin envelopes until processed.

Preparation —

Opercula – Tautog opercula were boiled for several minutes to remove any attached skin and muscle tissue. After boiling, opercula were examined to determine whether they were collected whole or in some way damaged. Opercula were allowed to dry and finally stored in new labeled coin envelopes.

Otoliths – Because of the small size of a tautog otolith, it required extra steps in preparation for ageing. An otolith was first baked in a Thermolyne 1400 furnace at 400°C for one to two minutes until it turned a medium brown color (caramel). The location of the core of the otolith was marked with a felt pen and the entire otolith was embedded in Loctite 349 adhesive, placed under UV light, and allowed to harden overnight. The otolith was then transversely sectioned through the felt pen mark with a low speed Buehler Isomet saw equipped with double wafering blades separated by a 0.5 mm spacer. The sectioned side of the otolith was then placed face down in a drop of Loctite 349 photo-active adhesive on a labeled glass slide and placed under ultraviolet light to allow the adhesive to harden (approximately ten minutes). The otolith section was then polished using a Buehler Ecomet 3 variable speed grinder-polisher with Mark V Laboratory 30-micron polishing film. After polishing, a thin layer of Flo-texx mounting medium was applied to the otolith section to increase light transmission through the translucent zones, which provided enhanced contrast and greater readability.

Readings — Opercula were aged on a light table with no magnification (Figure 1). Sectioned otoliths were aged by two different readers using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 2).

Figure 1. Operculum from a 13 year-old male tautog.

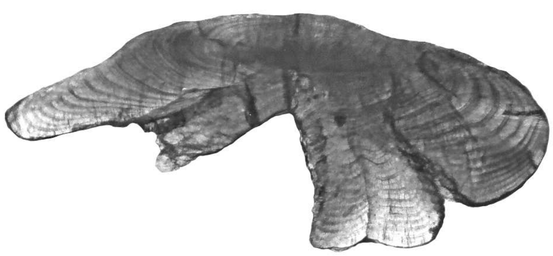


Figure 2. Otolith section from a 13 year-old male tautog. Same fish as Figure 1.

Two different readers aged all samples in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing

RESULTS

Opercula — Measurements of reader self-precision were relatively high, with both readers able to reproduce the ages of previously read opercula (Reader 1's CV = 7.5% and Reader 2's CV = 11.6%). In Figure 3 we present a graph of the results for between-reader operculum ageing precision. There was no evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 42.3$, df = 29, P =0.0527). The average between-reader coefficient of variation (CV) of 9.2% and was relatively high. The between-reader agreement for scale for one year or less was 93.8% of all aged fish. The high agreement between the readers and the high CVs were partially due to the sample dominated by younger fish.

The average operculum age for the sample was 4.1 years, and the standard deviation and standard error were 2.20 and 0.09, respectively. Year-class data (Figure 4) indicate that recruitment into the fishery occurred at age 1, which corresponds to the 2004 year-class for tautog caught in 2005. Year-class abundance was high for the 2000–2002 year-classes.

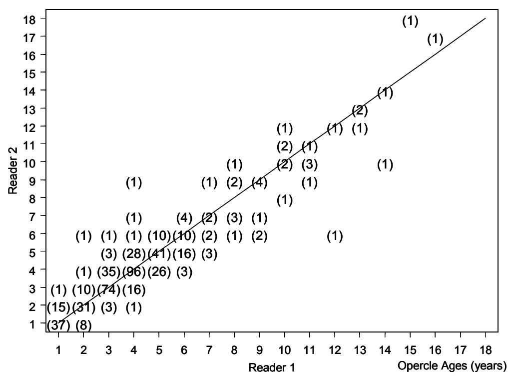


Figure 3. Between-reader comparison of operculum age estimates for tautog.

Otoliths — Measurements of reader self-precision were good, with both readers able to reproduce the ages of previously read otoliths (Reader 1's CV = 3.4% and Reader 2's CV = 5.4%). There was evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 36.2$, df = 24, $P = 0.0263$). In Figure 5 we present a graph of the results for between-reader otolith ageing precision. The average between-reader coefficient of variation (CV) of 4.1% was not significant.

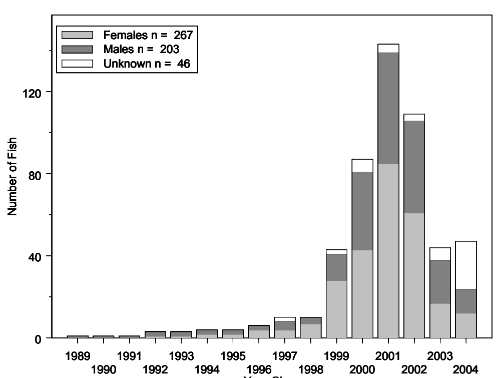


Figure 4. Operculum year-class distribution for tautog collected in 2005. Distributions are broken down by sex.

Of the 505 fish aged with otoliths, 16 age-classes (1 through 16) were represented. The average age for the sample was 4.0 years. The standard deviation and standard error were 2.32 and 0.10, respectively.

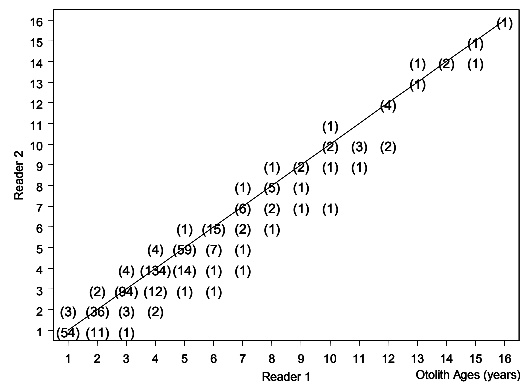


Figure 5. Between-reader comparison of otolith age estimates for tautog.

Comparison of Operculum and Otolith Ages — The between-structure average CV of 10.9% was comparable to the within structure CV's. There was evidence of systematic disagreement between otolith

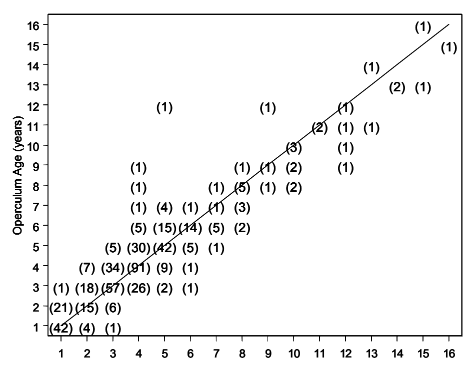


Figure 6. Comparison of otolith and operculum age estimates for tautog.

and operculum ages (test of symmetry, $\chi^2 = 66.7$, df $= 28$, $P < 0.0001$). Operculum were assigned a lower age than otoliths for 16% of the fish and 30% of the time were operculum assigned a higher age than otoliths (Figure 6). There was also evidence of bias between otolith and operculum ages using an age bias plot (Figure 7), again with operculum generally assigned higher ages for younger fish and lower ages for older fish than otoliths age estimates.

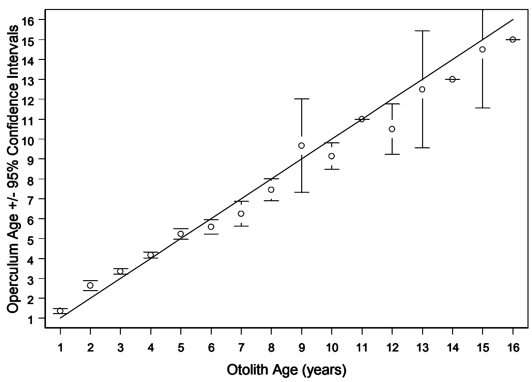


Figure 7. Age-bias plot for tautog otolith and operculum age estimates.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using operculum ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

White, G.G., J.E. Kirkley, and J.A. Lucy. 1997. Quantitative assessment of fishing mortality for tautog, *Tautoga onitis*, in Virginia. Preliminary report to the Virginia Marine Recreational Advisory Board and Virginia Marine Resources Commission. Newport News, VA.

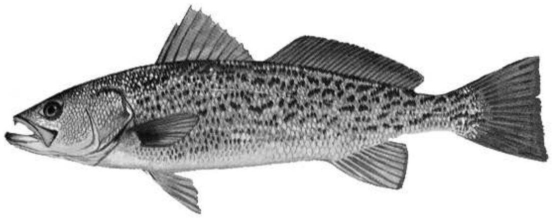
Table 1. The number of tautog assigned to each total length-at-age category for 516 fish sampled for operculum age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Totals
8 - 8.99	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
9 - 9.99	3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	7
10 - 10.99	16	11	3	0	0	0	0	0	0	0	0	0	0	0	0	0	30
11 - 11.99	24	15	9	1	2	0	0	0	0	0	0	0	0	0	0	0	51
12 - 12.99	3	7	7	5	3	1	0	0	0	0	0	0	0	0	0	0	26
13 - 13.99	0	7	34	27	4	0	2	0	0	0	0	0	0	0	0	0	74
14 - 14.99	1	0	24	41	16	2	1	0	0	0	0	0	0	0	0	0	85
15 - 15.99	0	1	16	31	23	11	1	0	0	0	0	0	0	0	0	0	83
16 - 16.99	0	0	9	24	11	3	2	1	1	0	1	0	0	0	0	0	52
17 - 17.99	0	0	6	9	14	12	0	1	1	1	0	0	0	0	0	0	44
18 - 18.99	0	0	0	4	8	4	1	4	0	1	0	0	0	0	0	0	22
19 - 19.99	0	0	0	0	5	9	2	2	1	0	0	0	0	0	0	0	19
20 - 20.99	0	0	0	0	1	0	0	0	2	1	0	1	1	0	0	0	6
21 - 21.99	0	0	0	0	0	1	0	1	1	1	0	1	0	1	1	0	7
22 - 22.99	0	0	0	0	0	0	1	1	0	0	1	1	1	0	0	1	6
23 - 23.99	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2
24 - 24.99	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Totals	47	44	109	143	87	43	10	10	6	4	4	3	3	1	1	1	516

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-class, based on operculum ages for tautog sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	N
8 - 8.99	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1
9 - 9.99	0.429	0.429	0.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7
10 - 10.99	0.533	0.367	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	30
11 - 11.99	0.471	0.294	0.176	0.020	0.039	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	51
12 - 12.99	0.115	0.269	0.269	0.192	0.115	0.038	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	26
13 - 13.99	0.000	0.095	0.459	0.365	0.054	0.000	0.027	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	74
14 - 14.99	0.012	0.000	0.282	0.482	0.188	0.024	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	85
15 - 15.99	0.000	0.012	0.193	0.373	0.277	0.133	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	83
16 - 16.99	0.000	0.000	0.173	0.462	0.212	0.058	0.038	0.019	0.019	0.000	0.019	0.000	0.000	0.000	0.000	0.000	52
17 - 17.99	0.000	0.000	0.136	0.205	0.318	0.273	0.000	0.023	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000	44
18 - 18.99	0.000	0.000	0.000	0.182	0.364	0.182	0.045	0.182	0.000	0.045	0.000	0.000	0.000	0.000	0.000	0.000	22
19 - 19.99	0.000	0.000	0.000	0.000	0.263	0.474	0.105	0.105	0.053	0.000	0.000	0.000	0.000	0.000	0.000	0.000	19
20 - 20.99	0.000	0.000	0.000	0.000	0.167	0.000	0.000	0.000	0.333	0.167	0.000	0.167	0.167	0.000	0.000	0.000	6
21 - 21.99	0.000	0.000	0.000	0.000	0.000	0.143	0.000	0.143	0.143	0.143	0.000	0.143	0.000	0.143	0.143	0.000	7
22 - 22.99	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.167	0.000	0.000	0.167	0.167	0.167	0.000	0.000	0.167	6
23 - 23.99	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	2
24 - 24.99	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	1
															Sample Size		516

Chapter 13
Weakfish



Cynoscion regalis

INTRODUCTION

A total of 756 weakfish, *Cynoscion regalis*, was collected by the VMRC's Stock Assessment Program for age and growth analysis in 2005. The average age was 2.3 years old, and the standard deviation and standard error were 0.80 and 0.03, respectively. Nine age classes (1 to 7, and 9 to 10) were represented, comprising fish from the 1995-1996 and 1998-2004 year-classes, with fish primarily from the 2002 through 2003 year-classes.

METHODS

Handling of collection — Otoliths were received by the Age & Growth Laboratory in labeled coin envelopes. Once in our hands, they were sorted based on date of capture, their envelope labels were verified against VMRC's collection data, and assigned unique Age and Growth Laboratory sample numbers. All otoliths were stored dry in labeled cell well trays.

Preparation — The first step in otolith preparation was to grind down the otolith in a transverse plane to its core using a Hillquist thin section machine's 320-mesh diamond cup wheel. To prevent distortion of the reading surface, the otolith was ground exactly perpendicular to the reading plane. The otolith's ground surface was then placed face down in a drop of Loctite 349 photo-active adhesive on a labeled glass slide and placed under ultraviolet light to allow the adhesive to harden. The Hillquist thin section machine's cup wheel was used again to grind the otolith, embedded in Loctite, to a thickness of 0.3 to 0.5 mm. Finally, a thin layer of Flo-texx mounting medium was applied to the otolith section to increase light transmission through the translucent zones, which provided enhanced contrast and greater readability.

Readings — Two different readers aged all sectioned otoliths using a Leica MZ-12 dissecting microscope with transmitted light and dark-field polarization at between 8 and 100 times magnification (Figure 1). Each reader aged all of the otolith sections using ageing criteria listed in Lowerre-Barbieri et al. (1994). All samples were aged in chronological order based on collection date, without knowledge of previously estimated ages or the specimen lengths. When the readers' ages agreed, that age was assigned to the fish. When the two readers

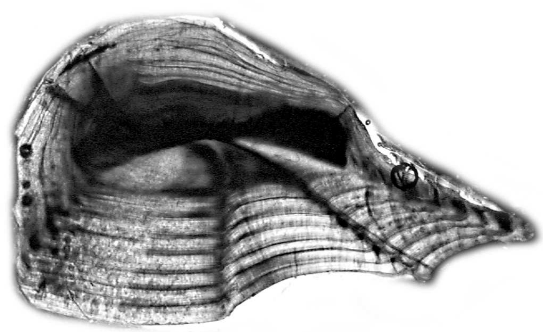


Figure 1. Sectioned otolith from a 7 year old female weakfish.

disagreed, both readers sat down together and re-aged the fish, again without any knowledge of previously estimated ages or lengths, and assigned a final age to the fish. When the readers were unable to agree on a final age, the fish was excluded from further analysis.

Comparison Tests — Age estimates from Reader 1 were plotted against age estimates from Reader 2 to assess deviation from 1:1 equivalence (Campana et al. 1995). A test for symmetry was used to detect any systematic difference between the two readers (Hoenig et al. 1995). Also, a random sub-sample of 50 fish was selected for second readings to measure reader precision and age reproducibility. To detect any changes or drift in our ageing methods, both readers re-aged otoliths of 50 randomly selected fish previously aged in 2000. We considered a reader to be biased if the readings revealed consistent over or under ageing.

RESULTS

The measurement of reader self-precision was high for both readers (Both readers had 0% CVs). There was no evidence of systematic disagreement between reader 1 and reader 2 (test of symmetry, $\chi^2 = 6.5$, df = 5, $P = 0.2577$). Figure 2 illustrates the between readers' precision of age estimates. The average coefficient of variation (CV) of 1.1% was not significant.

Of the 756 fish aged with otoliths, nine age classes were represented (Table 1). The average age was 2.3 years old, and the standard deviation and standard error were 0.80 and 0.03, respectively.

Year-class data (Figure 3) show that the fishery was comprised of nine year-classes, comprising fish from the 1995-1996 and 1998-2004 year-classes, with fish primarily from the 2002 through 2003 year-classes.

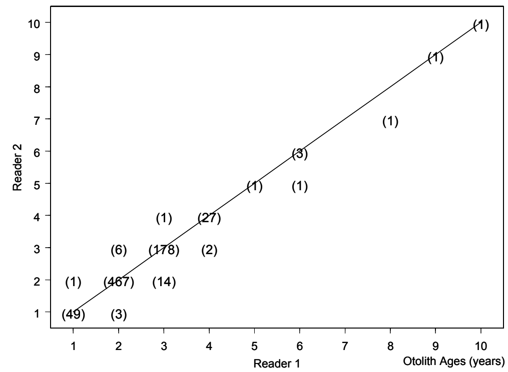


Figure 2. Between-reader comparison of otolith age estimates for weakfish.

Age-Length-Key — In Table 2 we present an age-length-key that can be used in the conversion of numbers-at-length in the estimated catch to numbers-at-age using otolith ages. The table is based on VMRC's stratified sampling of landings by total length inch intervals.

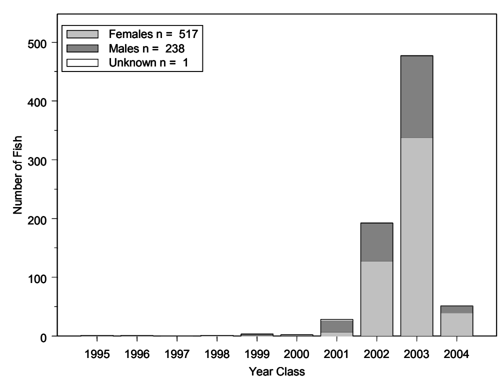


Figure 3. Year-class frequency distribution for weakfish collected for ageing in 2005. Distribution is broken down by sex.

REFERENCES

Campana, S.E., M.C. Annand, and J.I. McMillan. 1995. Graphical and statistical methods for determining the consistency of age determinations. Trans. Am. Fish. Soc. 124:131-138.

Hoenig, J.M., M.J. Morgan, and C.A. Brown. 1995. Analysing differences between two age determination methods by tests of symmetry. Can. J. Fish. Aquat. Sci. 52:364-368.

Lowerre-Barbieri, S.K., M.E. Chittenden Jr., and C.M. Jones. 1994. A comparison of a validated otolith method to age weakfish, *Cynoscion regalis*, with the traditional scale method. Fish Bull. 92:555-568.

S-Plus. 1999. S-Plus 4.5 Guide to Statistics. Data Analysis Products Division. Math Soft, Inc. Seattle, Washington.

Table 1. The number of weakfish assigned to each total length-at-age category for 756 fish sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	9	10	Totals
8 - 8.99	6	2	0	0	0	0	0	0	0	8
9 - 9.99	30	83	8	0	0	0	0	0	0	121
10 - 10.99	11	280	52	1	0	0	0	0	0	344
11 - 11.99	0	64	50	4	0	0	0	0	0	118
12 - 12.99	0	28	24	6	0	0	0	0	0	58
13 - 13.99	1	9	21	7	0	0	0	0	0	38
14 - 14.99	2	5	12	2	0	0	0	0	0	21
15 - 15.99	1	5	11	4	0	0	0	0	0	21
16 - 16.99	0	0	8	1	0	0	0	0	0	9
17 - 17.99	0	1	4	1	0	0	0	0	0	6
18 - 18.99	0	0	2	1	0	0	0	0	0	3
21 - 21.99	0	0	0	1	0	0	0	0	0	1
27 - 27.99	0	0	0	0	1	0	0	0	0	1
28 - 28.99	0	0	0	0	1	1	0	0	0	2
29 - 29.99	0	0	0	0	0	0	1	0	0	1
30 - 30.99	0	0	0	0	0	1	0	1	1	3
31 - 31.99	0	0	0	0	0	1	0	0	0	1
Totals	51	477	192	28	2	3	1	1	1	756

Table 2. Age-Length key, as proportions-at-age in each 1 inch length-intervals, based on otolith ages for weakfish sampled for age determination in Virginia during 2005.

Length 1-inch intervals	Age (years) 1	2	3	4	5	6	7	9	10	N
8 - 8.99	0.750	0.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000	8
9 - 9.99	0.248	0.686	0.066	0.000	0.000	0.000	0.000	0.000	0.000	121
10 - 10.99	0.032	0.814	0.151	0.003	0.000	0.000	0.000	0.000	0.000	344
11 - 11.99	0.000	0.542	0.424	0.034	0.000	0.000	0.000	0.000	0.000	118
12 - 12.99	0.000	0.483	0.414	0.103	0.000	0.000	0.000	0.000	0.000	58
13 - 13.99	0.026	0.237	0.553	0.184	0.000	0.000	0.000	0.000	0.000	38
14 - 14.99	0.095	0.238	0.571	0.095	0.000	0.000	0.000	0.000	0.000	21
15 - 15.99	0.048	0.238	0.524	0.190	0.000	0.000	0.000	0.000	0.000	21
16 - 16.99	0.000	0.000	0.889	0.111	0.000	0.000	0.000	0.000	0.000	9
17 - 17.99	0.000	0.167	0.667	0.167	0.000	0.000	0.000	0.000	0.000	6
18 - 18.99	0.000	0.000	0.667	0.333	0.000	0.000	0.000	0.000	0.000	3
21 - 21.99	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	0.000	1
27 - 27.99	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	0.000	1
28 - 28.99	0.000	0.000	0.000	0.000	0.500	0.500	0.000	0.000	0.000	2
29 - 29.99	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	1
30 - 30.99	0.000	0.000	0.000	0.000	0.000	0.333	0.000	0.333	0.333	3
31 - 31.99	0.000	0.000	0.000	0.000	0.000	1.000	0.000	0.000	0.000	1
								Sample Size		756

Chapter 14

INTRODUCTION

Because the VMRC uses an earlier version of Microsoft ACCESS ('97) than the ODU Age & Growth Laboratory, we have experience more problems with data-entry errors than is demanded by good laboratory practice. For this reason, we developed written and illustrated protocols that are used by staff of the Age & Growth Laboratory whenever we enter new data or pass data between ODU and VMRC. The protocols follow.

VMRC Data Handling One:

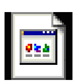
Part 1:

Protocol to convert the VMRC Access database into the '97-2003'Microsoft Excel format used in managing fish collections at CQFE.

Written with the inexperienced user in mind, step-by-step instructions guide the user through the download and conversion of the VMRC Microsoft Access Database into the '97' Microsoft Excel format. The "VMRC Data Handling training folder" is an example folder used to explain the steps of the conversion of Access data to the Excel format. The month for which the examples represent is June. This is the biological and geographical data for all hard-part collections up until the last day of June that are being added to the existing database. There will be many files to sort through when the actual data folder is in use. Pay close attention to make certain the correct folders and files are selected.

* <u>**All underlined notations**</u> are representative of variables within each month and year. This wording should not be used literally when saving files or folders.
* <u>**appropriate month**</u>: the new data for the month that is being added to the existing database. This will change monthly as new additions are added to the database.
* <u>**appropriate year**</u>: is the year in which the data was collected and the folder in which it is stored. The yearly calendar incorporates dates from January to December.
* **".mdb"** : Format that allows files to be opened using Microsoft Access 2000

Step 1.

Open the  email attachment from VMRC by **Left-clicking** the floppy disc icon. 

Giveto.ok

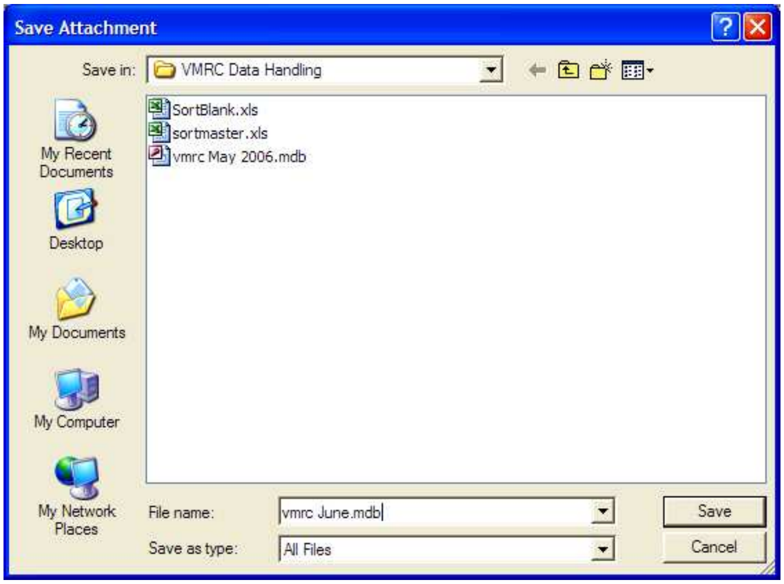
Step 2.

Save the **Giveto.ok** file using the network drive

Cqfe on 'Monarch_sci1_server\sci1\user\Sci', also known as the "**J**" drive.

The file should be saved in the "**J:\everyone\Ageinglab\data\\<u>appropriate year</u>\all**" folder as:

"**vmrc <u>appropriate month</u>.mdb**".



Step 3.

Close the email and web pages from which the data was retrieved.

Step 4.

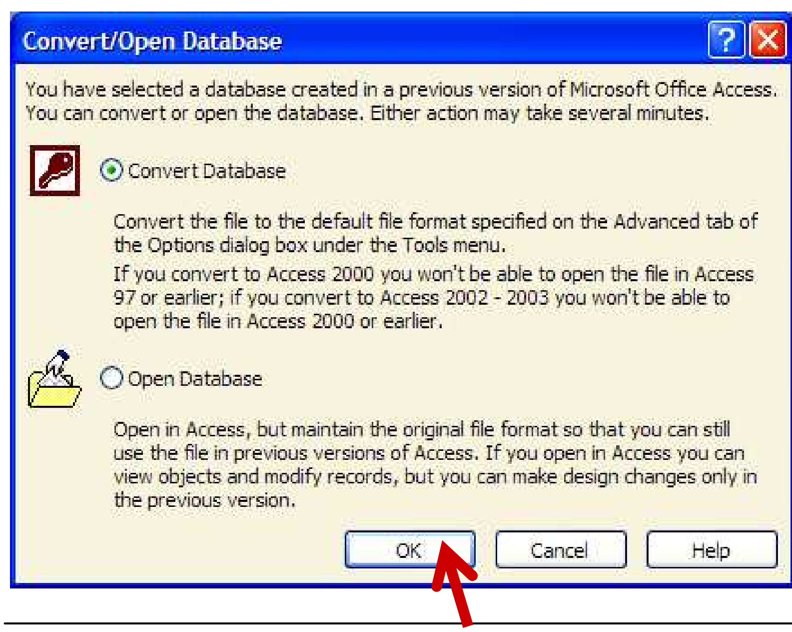
Open the "**J:\everyone\Ageinglab\data\<u>appropriate year</u>\all**" folder.

Step 5.

Open the "**vmrc <u>appropriate month</u>.mdb**" file that was just created.

Step 6.

Left Click **OK** when prompted to convert the database to the Microsoft Access 2000.

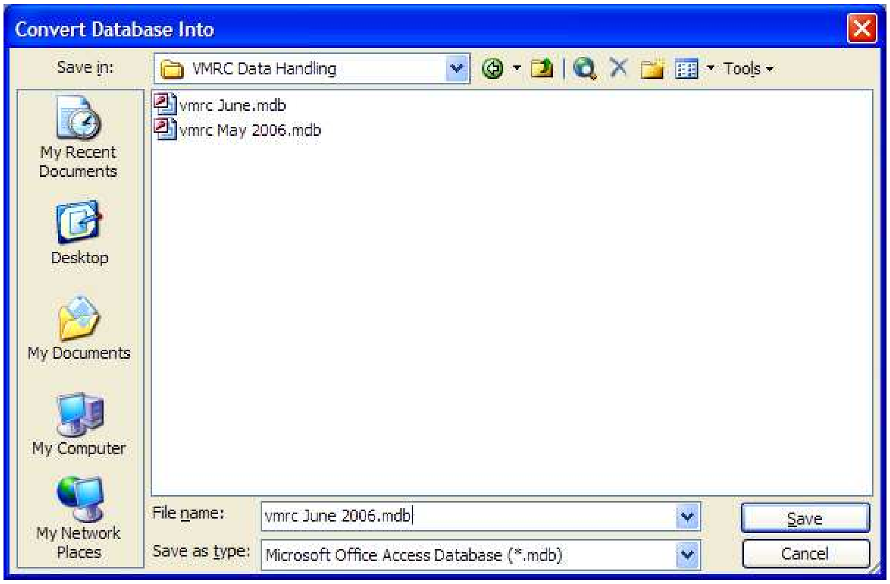


Step 7.

When converting the file into a Microsoft Access database, save the file as:

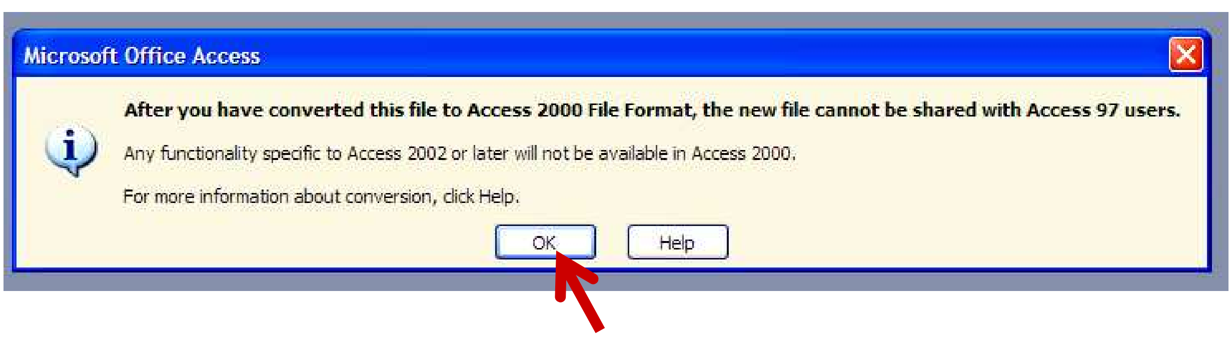
"**vmrc __appropriate month year__.mdb**" in the

"**J:\everyone\Ageinglab\data__appropriate year__\all**" folder.



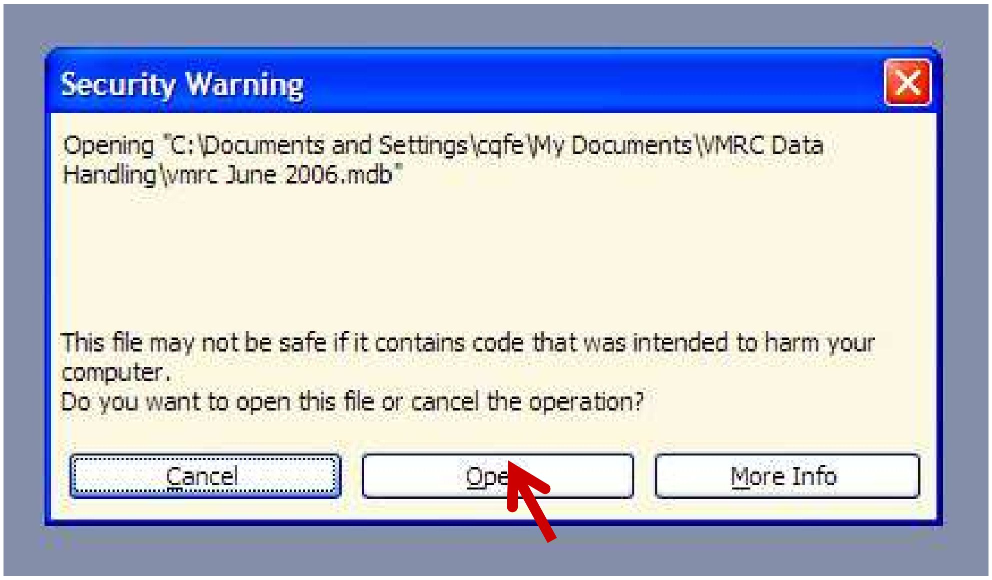
Step 8.

Left Click **OK** for the conversion.



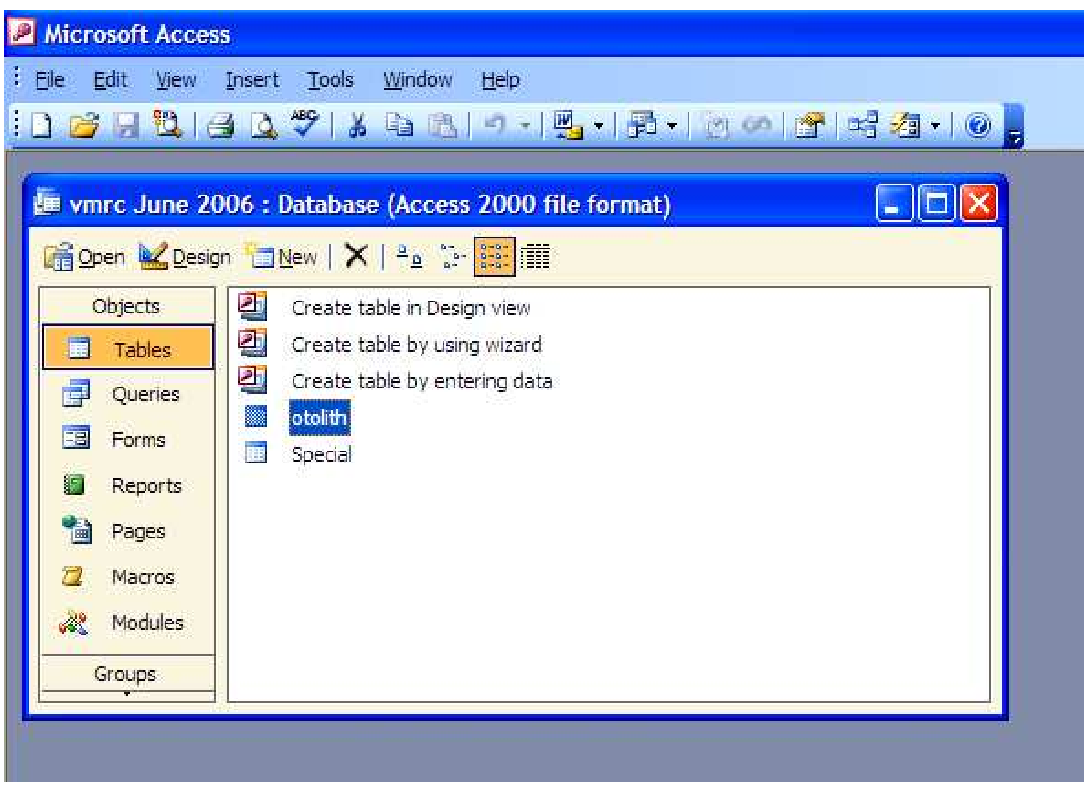
Step 9.

Left Click **OPEN** to bypass the security warning.



Step 10.

There should now be a **Microsoft Access** window containing an additional window with the newly converted data: **vmrc appropriate month year** (Access 2000 file format)



Step 11.

Minimize the Microsoft Access window.

Step 12.

Go to the "**J:\everyone\Ageinglab\data\appropriate-year\all**" folder.

Step 13.

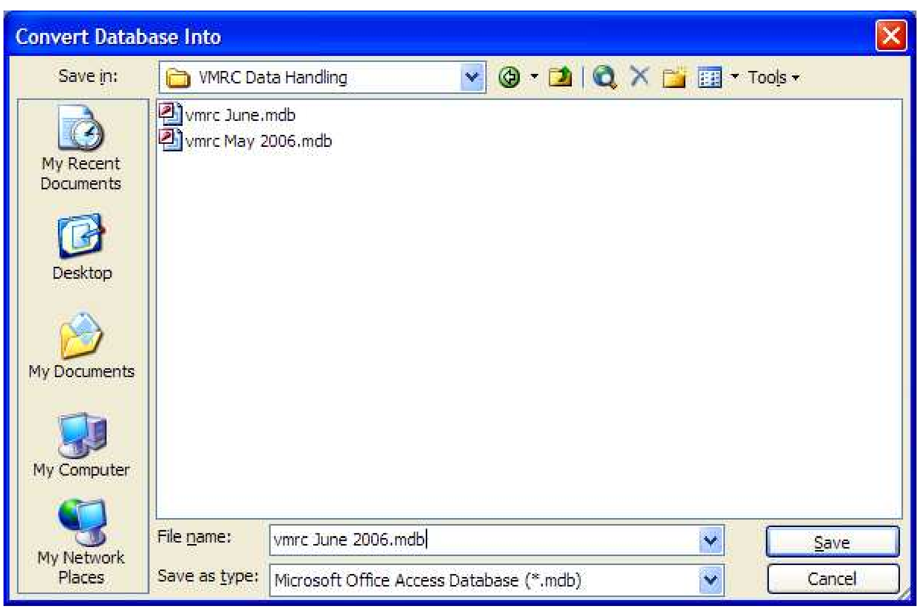
Delete the "**vmrc month.mdb**" file so that it isn't confused with the new Access 2000 file format that was just created.

Step 14.

Open the previous month's Microsoft Access 2000 database file found in the

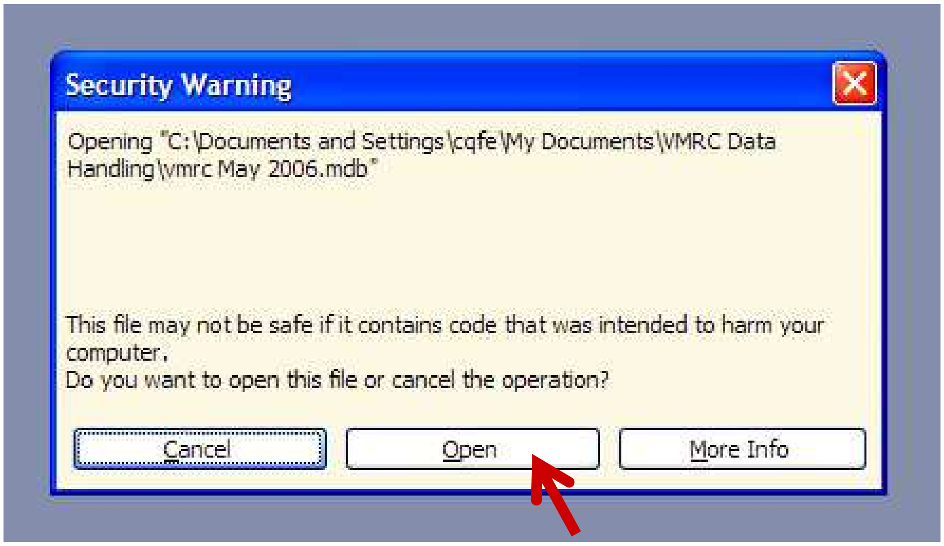
"**J:\everyone\Ageinglab\data\appropriate-year\all**" folder. (in this case it would be

"**vmrc May 2006.mdb**" because you are working with the June database)



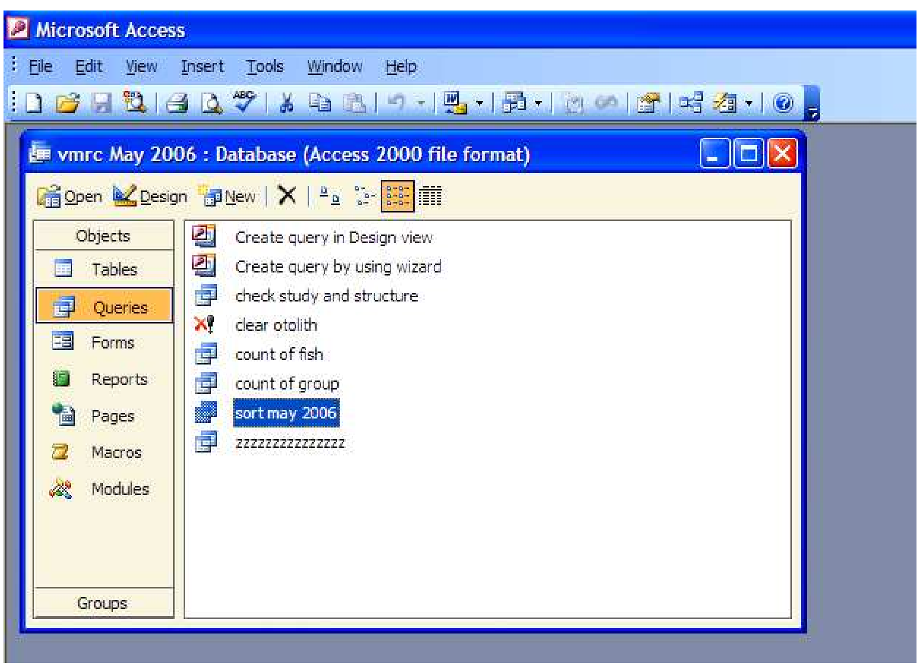
Step 15.

Left Click **OPEN** to bypass the security warning.



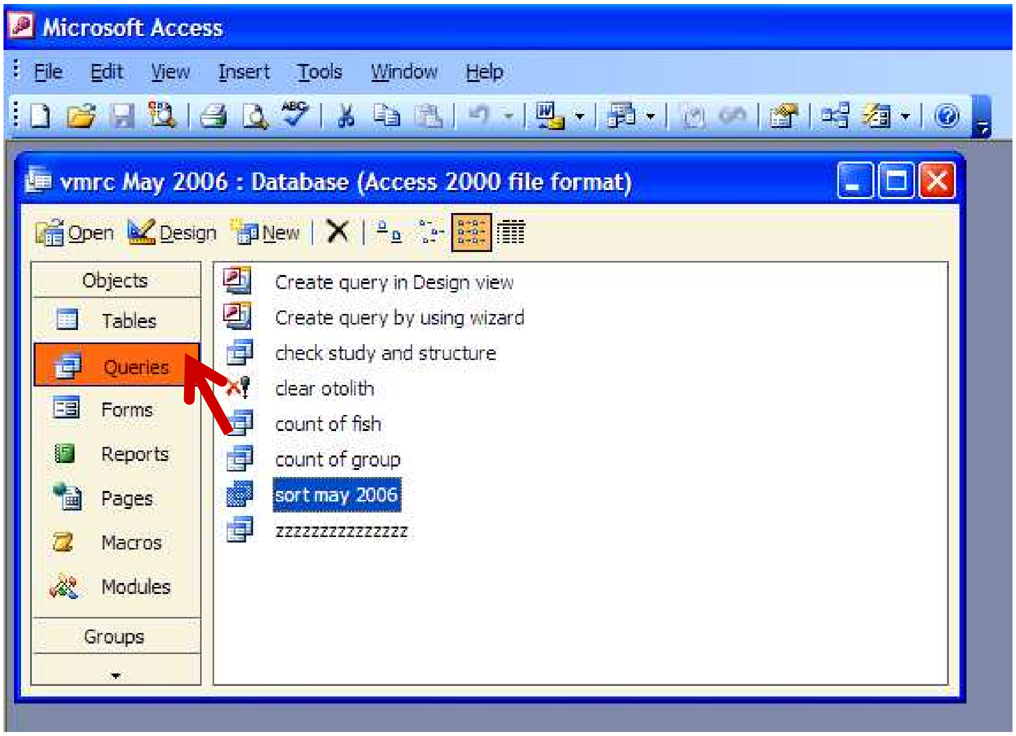
Step 16.

There should now be a **Microsoft Access** window containing an additional window with the **vmrc <u>previous month's</u> Database** (Access 2000 file format).



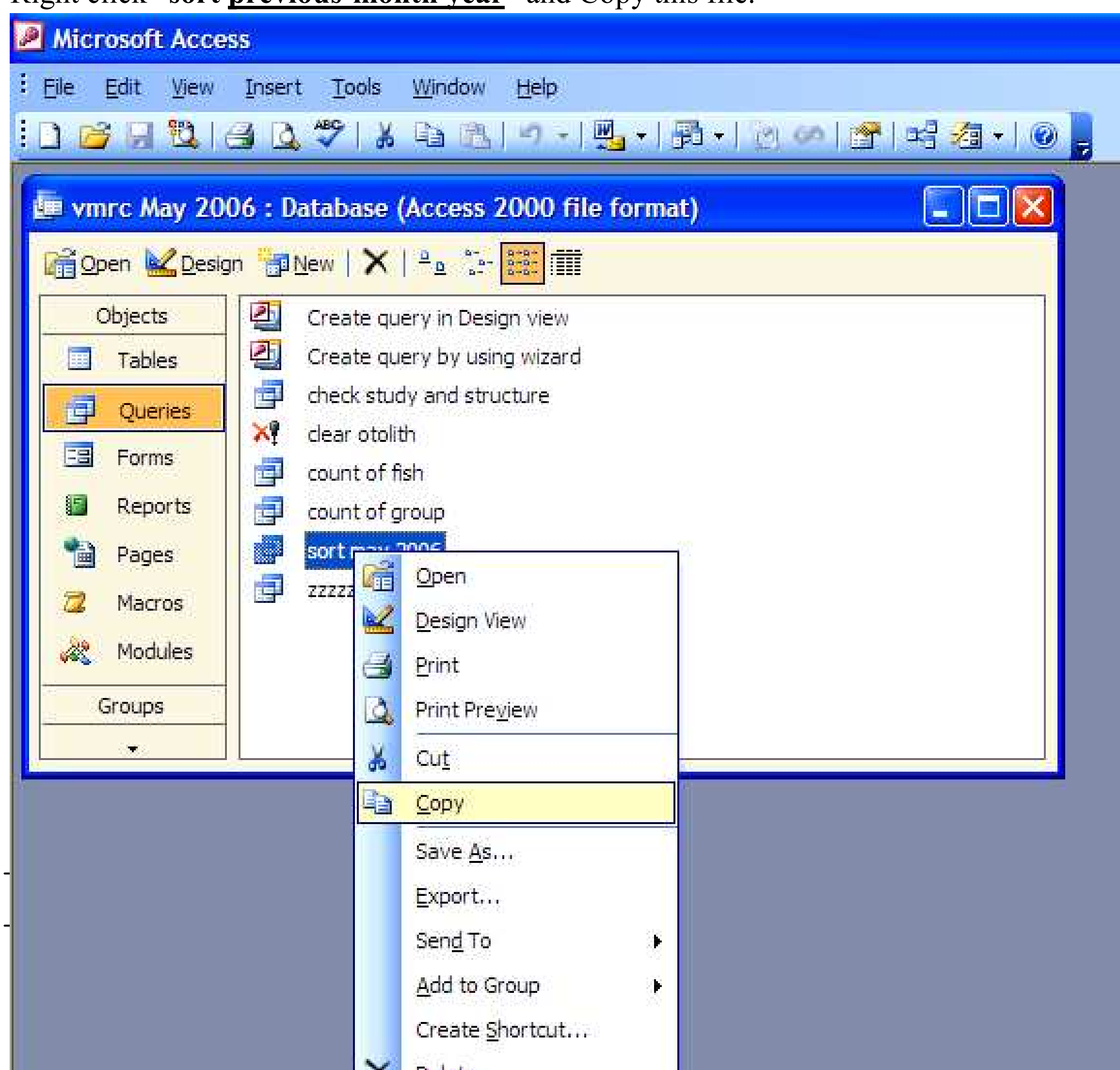
Step 17.

In the vmrc Database window, under the **Objects** heading, left click **Queries.**



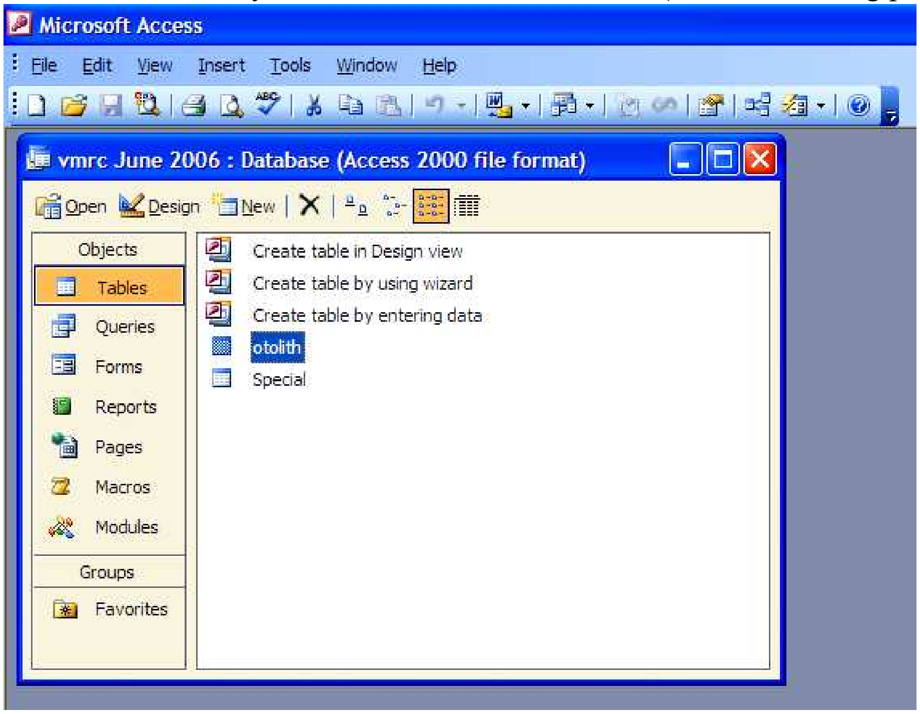
Step 18.

Right click "**sort <u>previous-month year</u>**" and Copy this file.



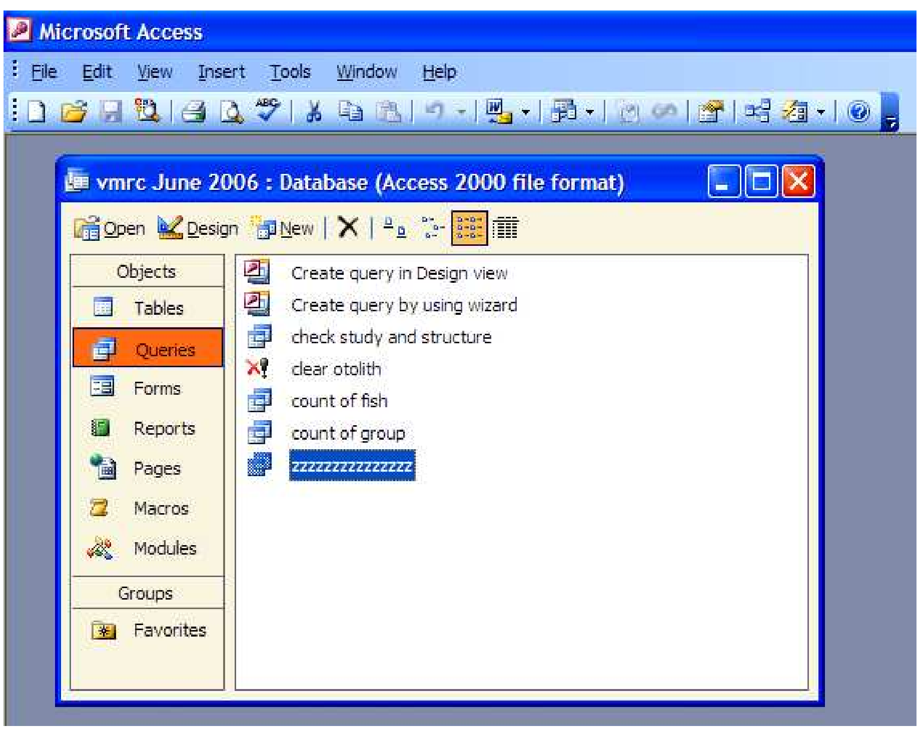
Step 19.

Maximize the newly created Microsoft Access file (June for training purposes).



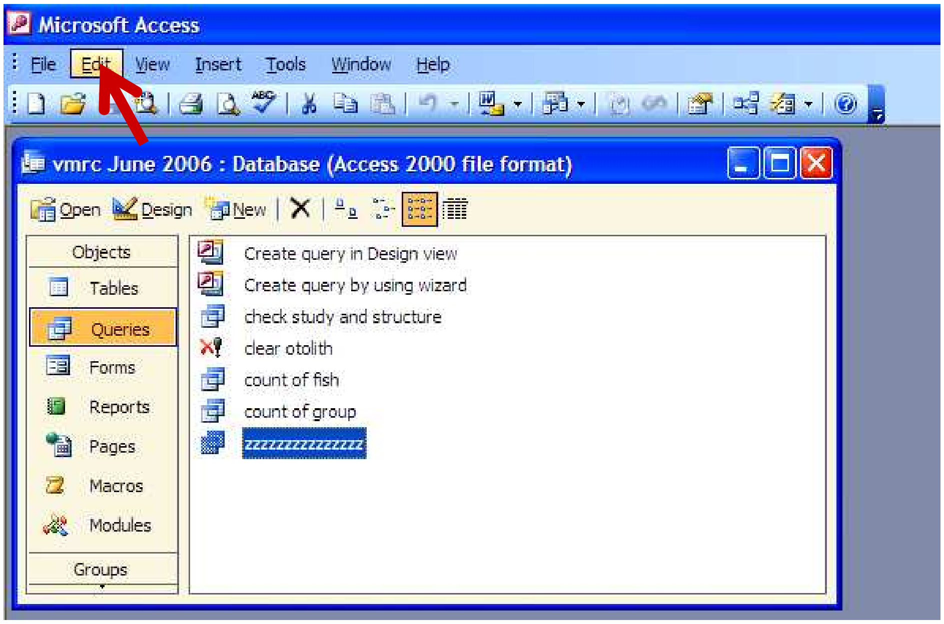
Step 20.

In the vmrc Database window, under the **Objects** heading, left click **Queries**.



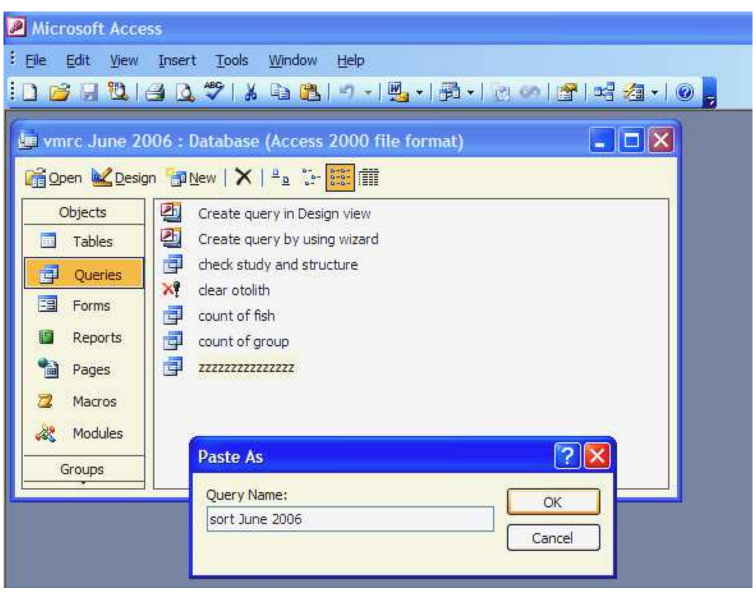
Step 21.

Left click the "**zzzzzzzzzzzzzzz**" query and using the **Edit** key on the Microsoft Access toolbar paste "**sort previous-month year**" in this location.



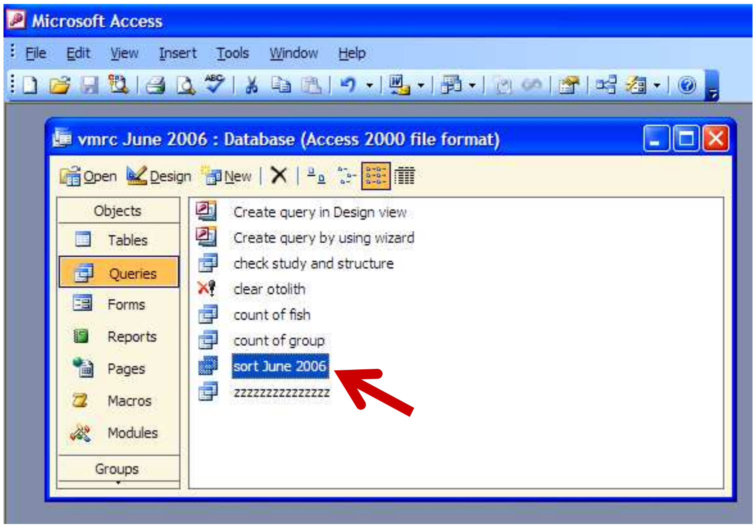
Step 22.

Name the query "**sort new- month year**" and save it. (in this case it will be sort June 2006). Left click **OK** to save the operation.



Step 23.

The "**sort <u>new-month year</u>"** file should now be listed in the **Queries** folder.



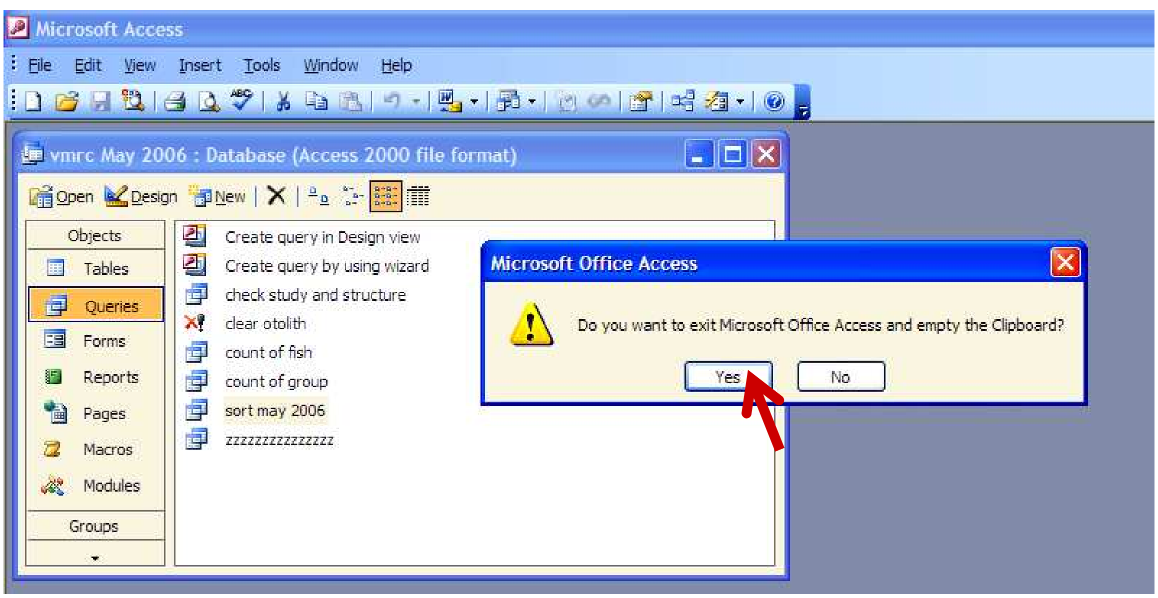
Step 24.

Minimize the "**vmrc <u>new month year</u>**" (June) Microsoft Access screen.

Step 25.

Close the Microsoft Access screen from the previous month's data.

Left click **YES** to exit and empty the clipboard

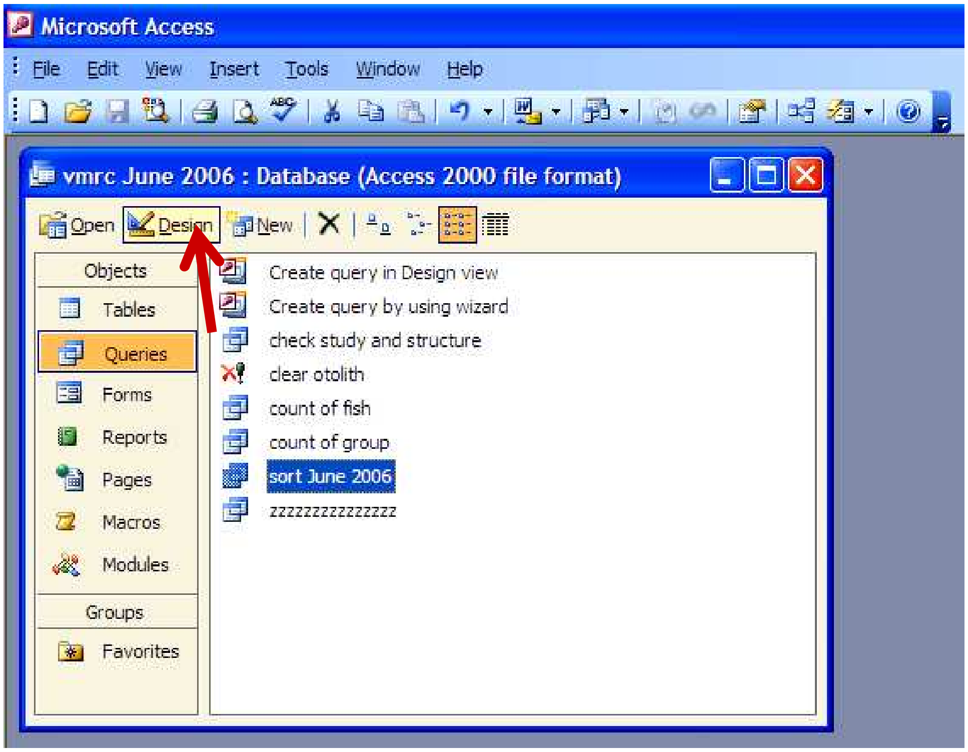


Step 26.

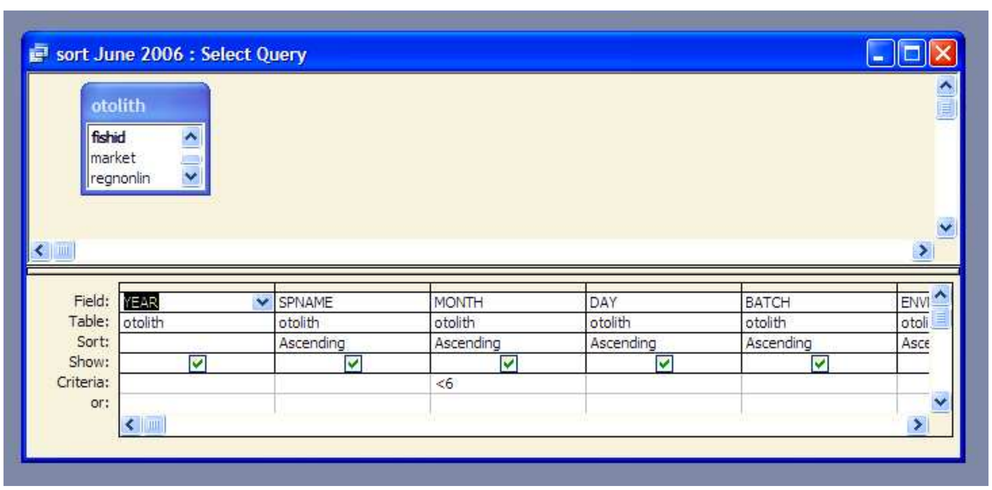
Maximize the newly created Microsoft Access database (June).

Step 27.

Select **Design** on the database window.

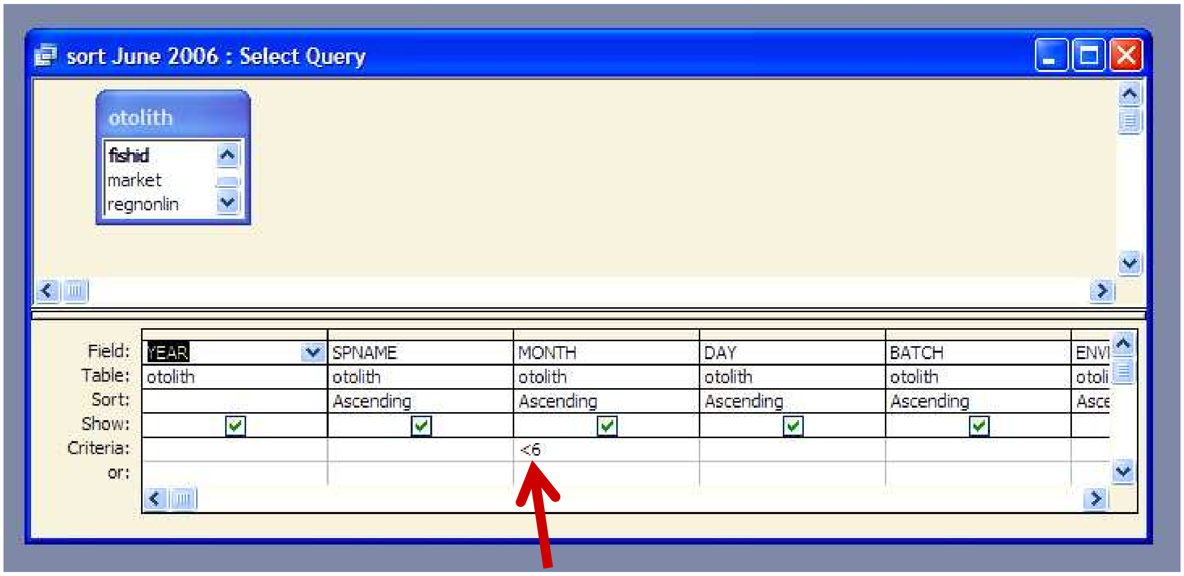


This will bring up the window "**sort month year: Select Query**" window.

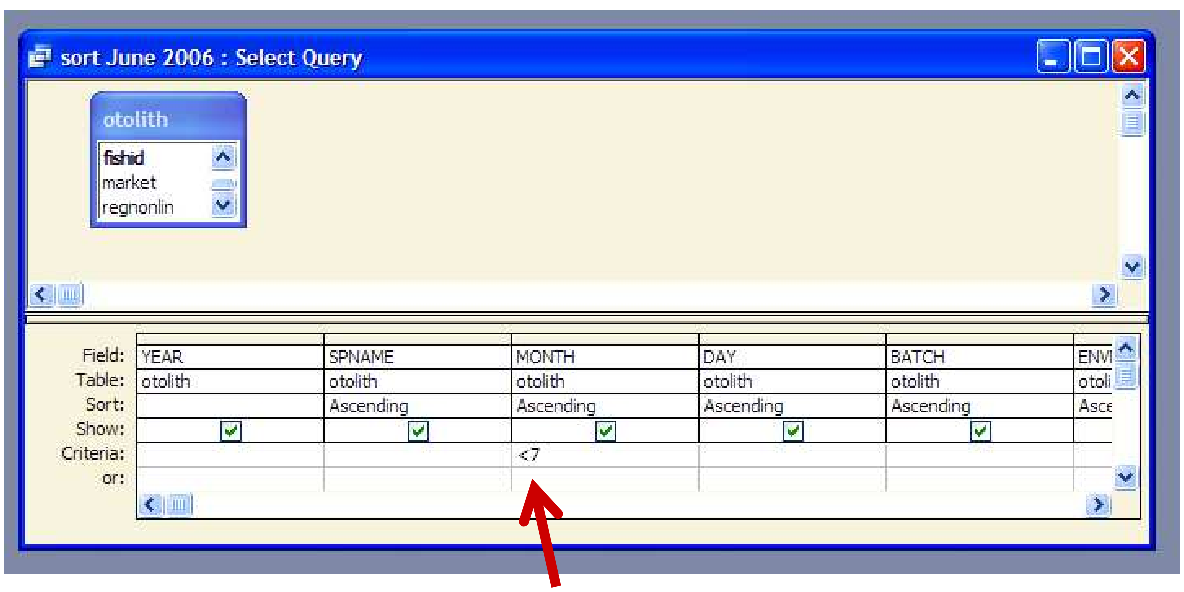


Step 28.

In the row for criteria, change the number under the month column to include all months up to the newest data added.



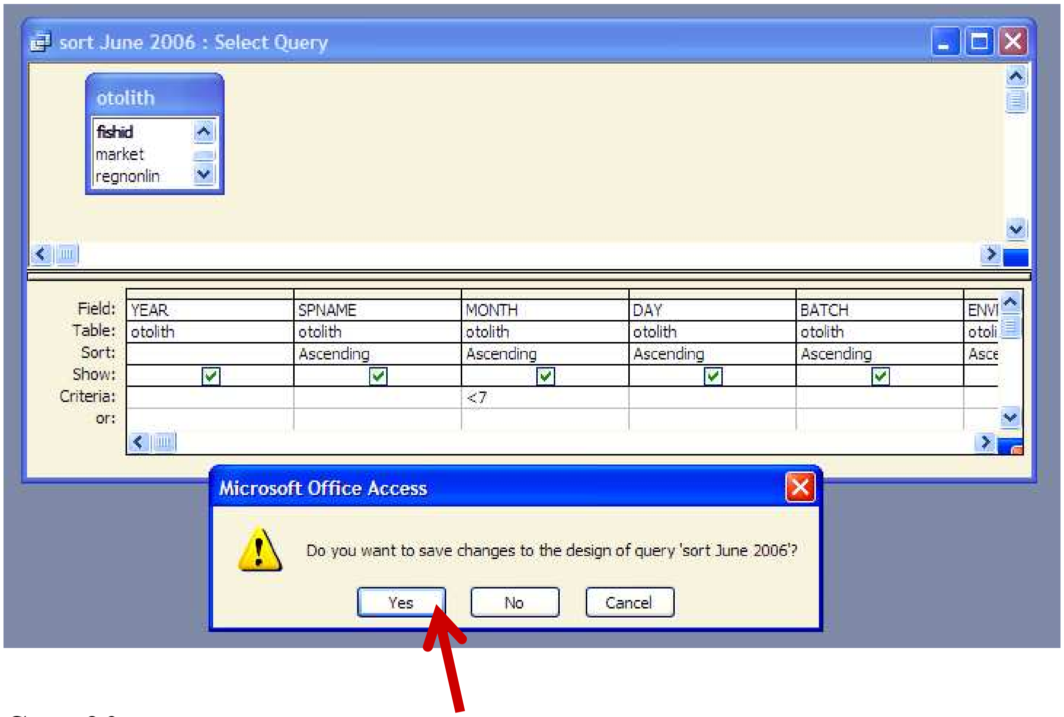
For this example, we are adding June data so the number needs to change to 7 so that all months with a numerical value less then 7 are included in the sort. June has a numerical value of 6. With no increase in this number, the sort would only go up until May (5).



Step 29.

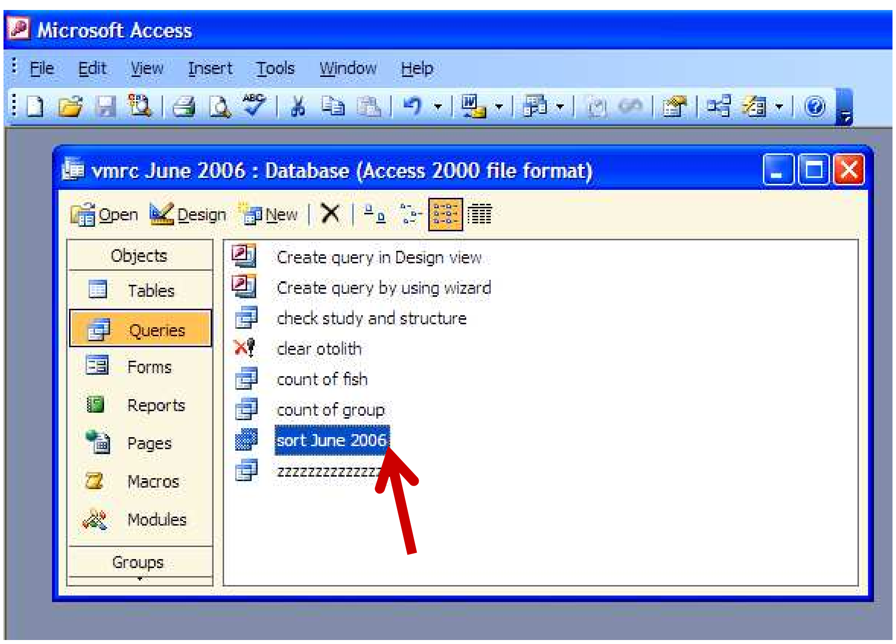
Close the Select Query window.

Left Click **YES** to save the changes.



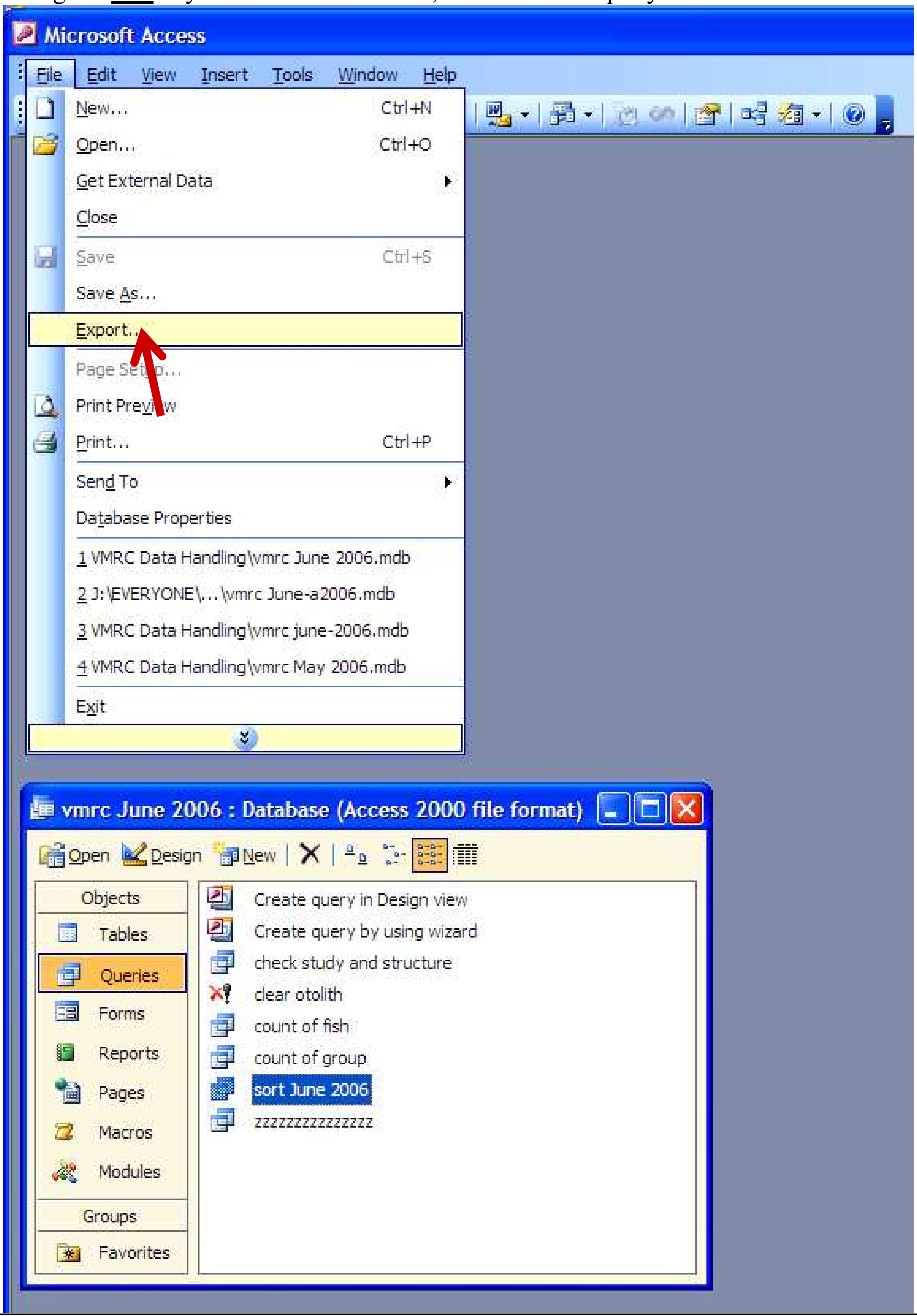
Step 30.

In the **Queries** folder Left click "**sort <u>month year</u>**" to highlight.



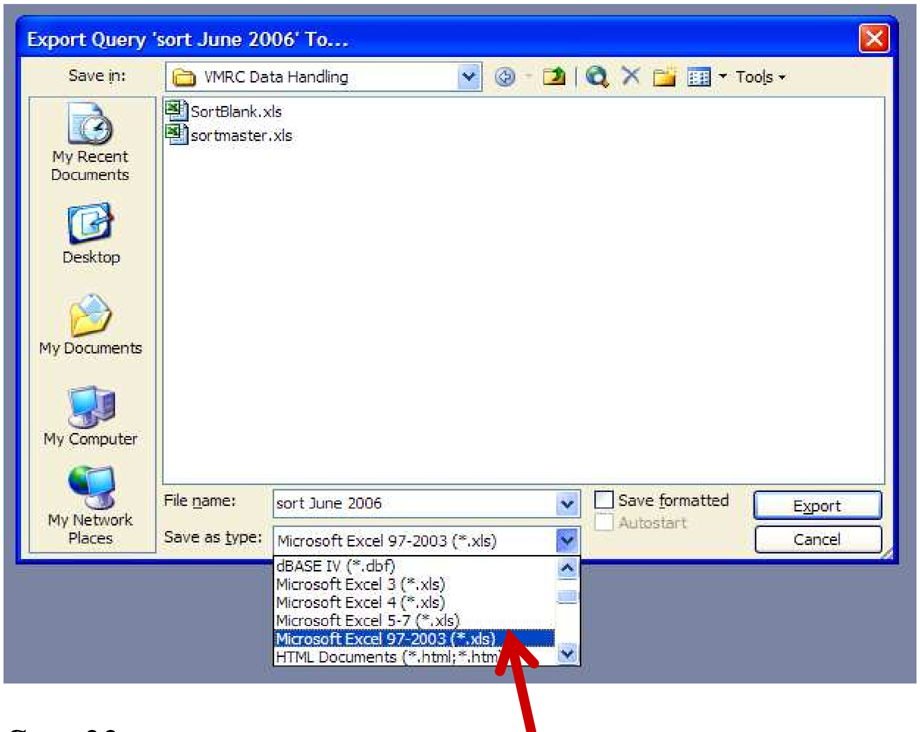
Step 31.

Using the **<u>File</u>** key on the Access toolbar, **EXPORT** the query as an excel 97-03 file.



Step 32.

Using the **Microsoft Excel 97-2003(*.xls) format**, name the file "**sort <u>month year</u>**" and save it in the "**J:\everyone\Ageinglab\data\<u>appropriate year</u>\all**" folder.



Step 33.

Click the **Save formatted** square before exporting the file**.**

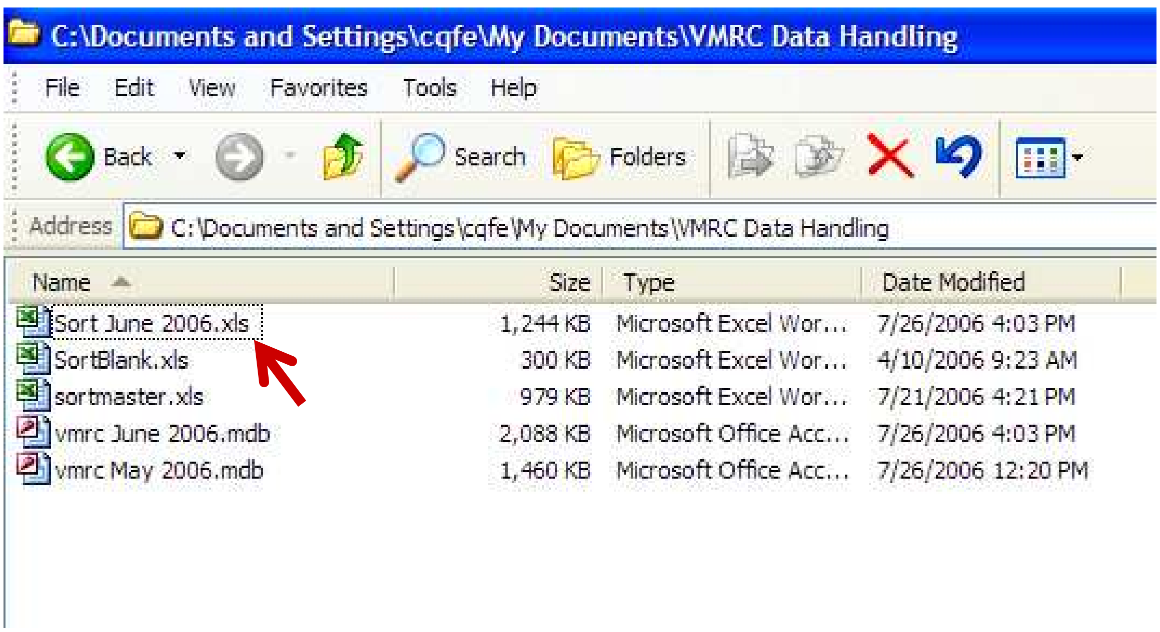
Step 34.

Close the Microsoft Access window.

Step 35.

Open the "**J:\everyone\Ageinglab\data\<u>appropriate-year</u>\all**" folder.

The "**sort <u>new-month's-data-year</u>**" Microsoft Excel 2000 file can now be found in this folder.



This completes the first Part 1 of VMRC Data Handling One.

Part 2 will take the user through the process of organizing and adding the new Microsoft Excel 97 data to a master file.

VMRC Data Handling One:

Part 2:

Protocol to move recently acquired and converted VMRC fish collection data to the CQFE Master file using Microsoft Excel .

Written with the inexperienced user in mind, step-by-step instructions guide the user through the transfer of monthly data collections from VMRC in the '97-2003' Microsoft Excel format to the yearly Master file utilized at CQFE. The "VMRC Data Handling training folder" is an example folder used to explain the steps of the transition. The month for which the examples represent is June. This is the biological and geographical data for all hard-part collections up until the last day of June that are being added to the existing Master file. There will be many files to sort through when the actual data folder is in use. Pay close attention to make certain the correct folders and files are selected.

* **All underlined notations** are representative of variables within each month and year. This wording should not be used literally when saving files or folders.
* **appropriate month**: the new data for the month that is being added to the existing database. This will change monthly as new additions are added to the database.
* **appropriate year**: is the year in which the data was collected and the folder in which it is stored. The yearly calendar incorporates dates from January to December.

Step 1.

Using the network drive **Cqfe on 'Monarch_sci1_server\sci1\user\Sci'** also known as the "**J**" drive find the folder: "**J:\everyone\Ageinglab\data\appropriate year\all**".

Step 2.

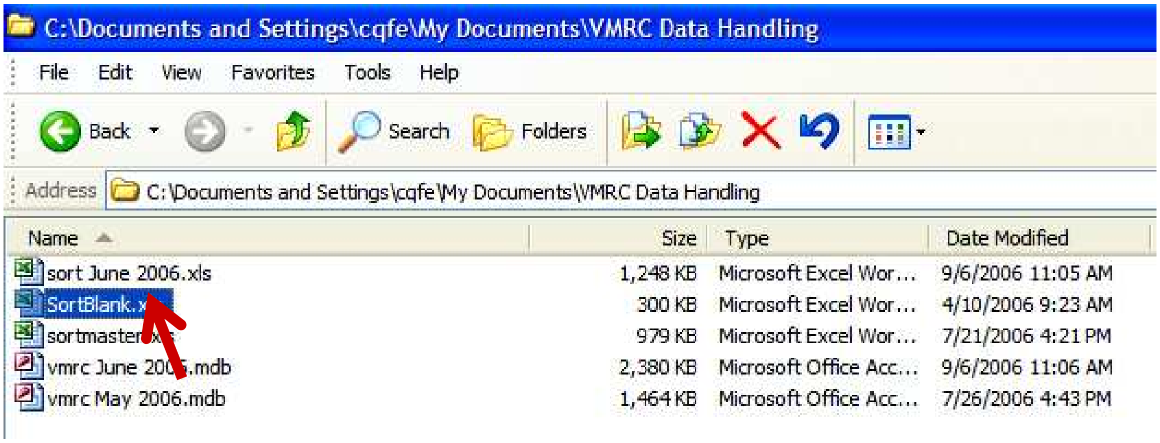
Open the folder

The user should see many "**.mdb**", "**.ok**" and "**.xls**" files. At this stage in the data handling procedure, only the "**.xls**" files should be utilized.

Step 3.

In the folder "**J:\everyone\Ageinglab\data\appropriate year\all**", open the

"SortBlank.xls" file. 

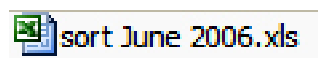


Step 4.

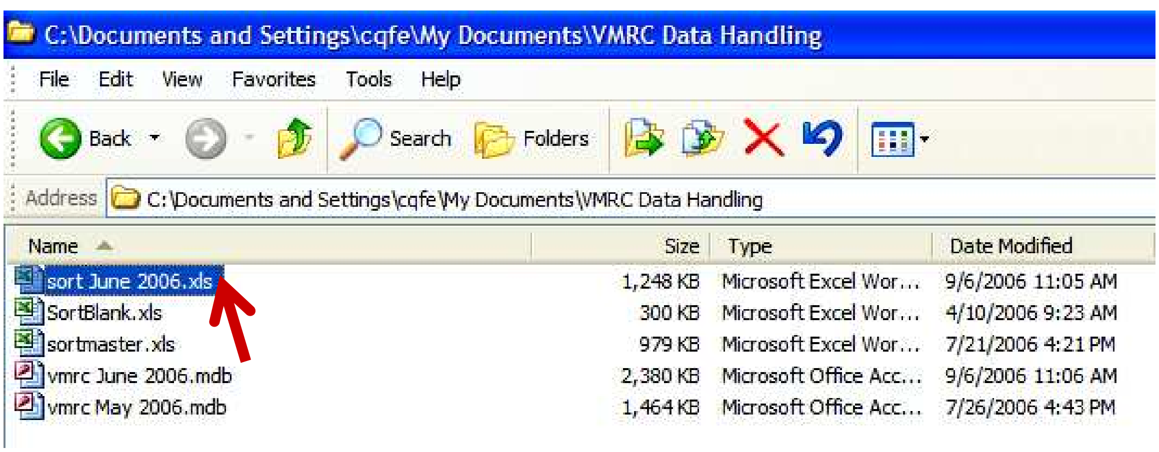
Minimize this file after opening.

Step 5.

Open the "**.xls**" file "sort **appropriate month year**.xls"

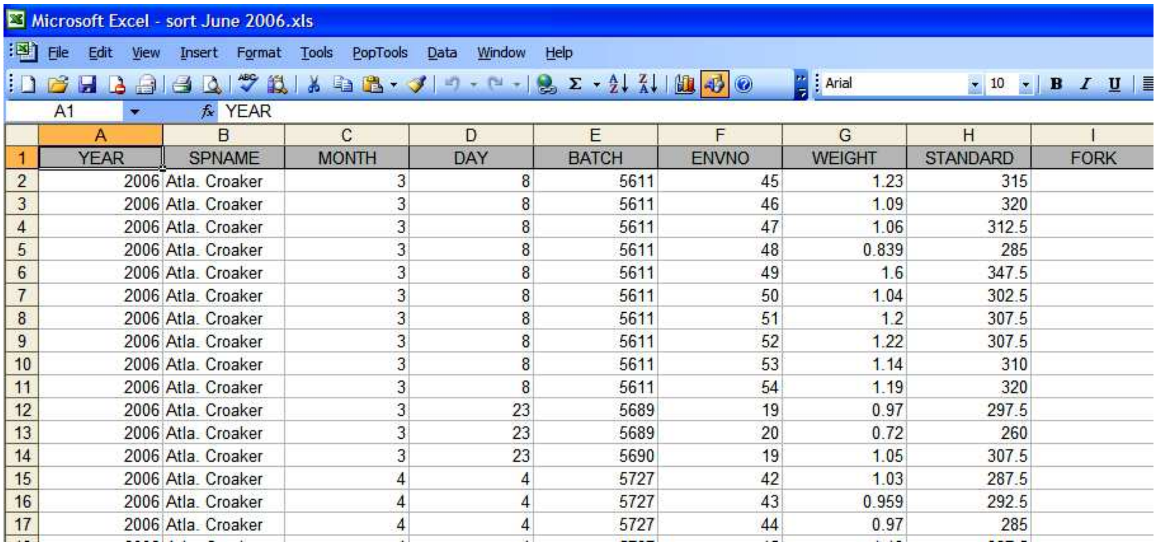


found in the "**J:\everyone\Ageinglab\data\<u>appropriate year</u>\all**" folder also. Use the month of June's file when working on data management in July because it includes all data up until the last day of June. In August, the July file will be used to update the Master file.



Step 6.

In the "sort **appropriate month year**.xls" file the user should see an excel spreadsheet with many column headings.



Step 7.

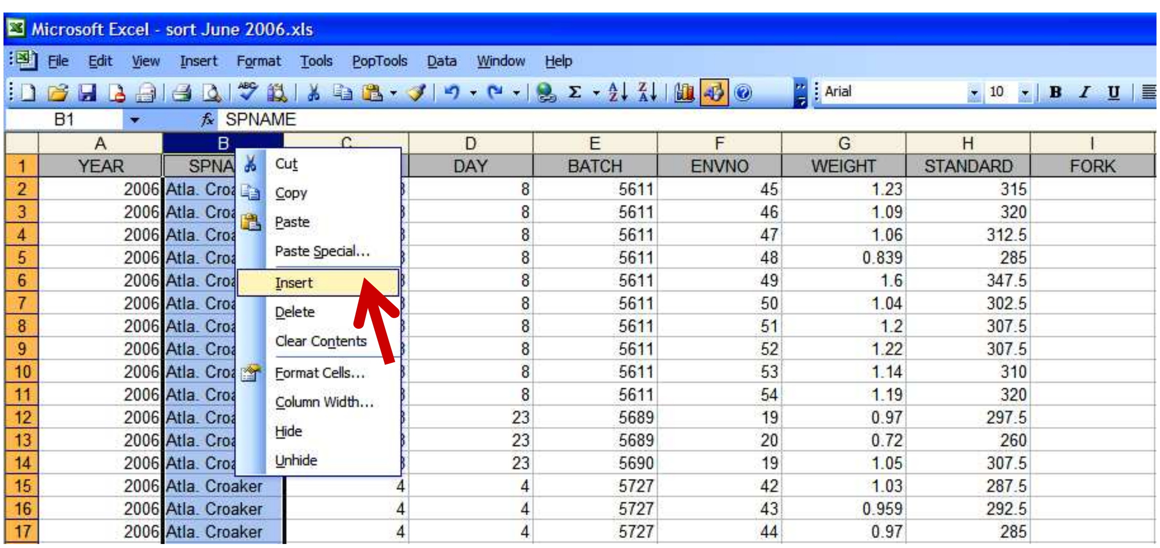
Scroll the page to the far left and uppermost position of the excel spreadsheet.

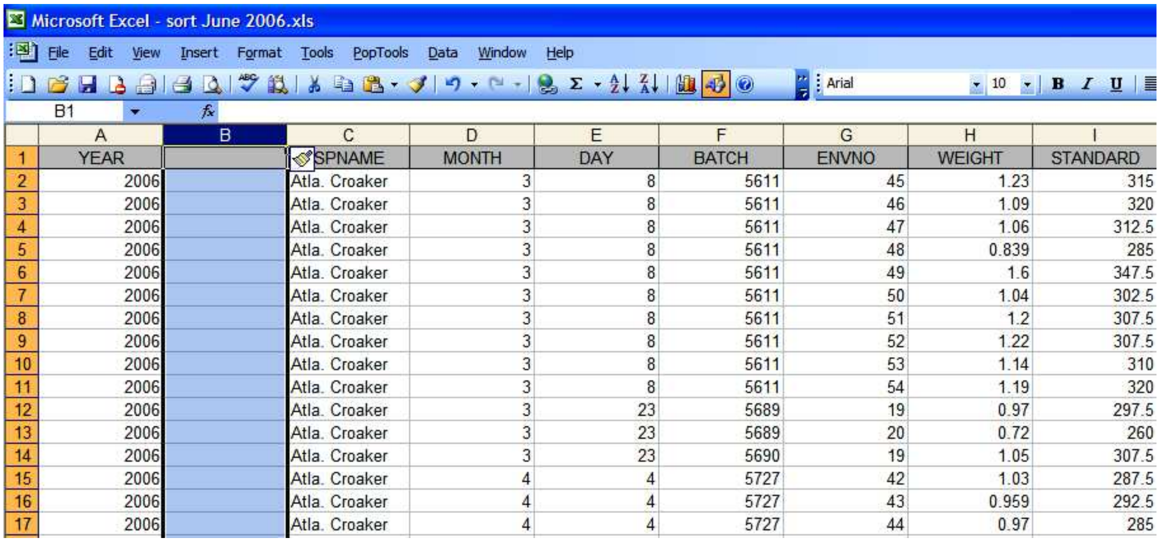
Step 8.

Right click the **SPNAME** column heading.

Step 9.

Left click **Insert,** placing a blank column between the **YEAR** and **SPNAME** columns.





Step 10.

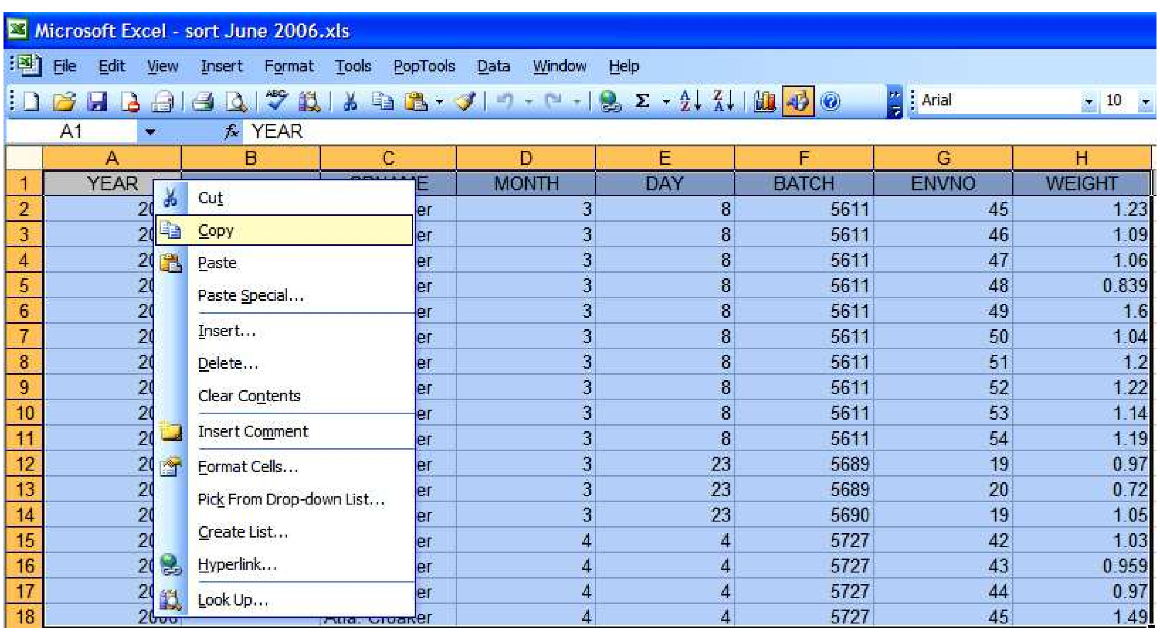
Starting with the **YEAR** column heading, hold the left mouse button down and while scrolling the mouse use this to highlight every row and column on the spreadsheet that contains data.

Step 11.

Right click the mouse over the highlighted area.

Step 12.

Copy the entire highlighted portion of the spreadsheet.



Step 13.

Maximize the "SortBlank.xls" file.

Step 14.

Find the uppermost, left-handed corner of the sheet with the tab labeled "Sort master".

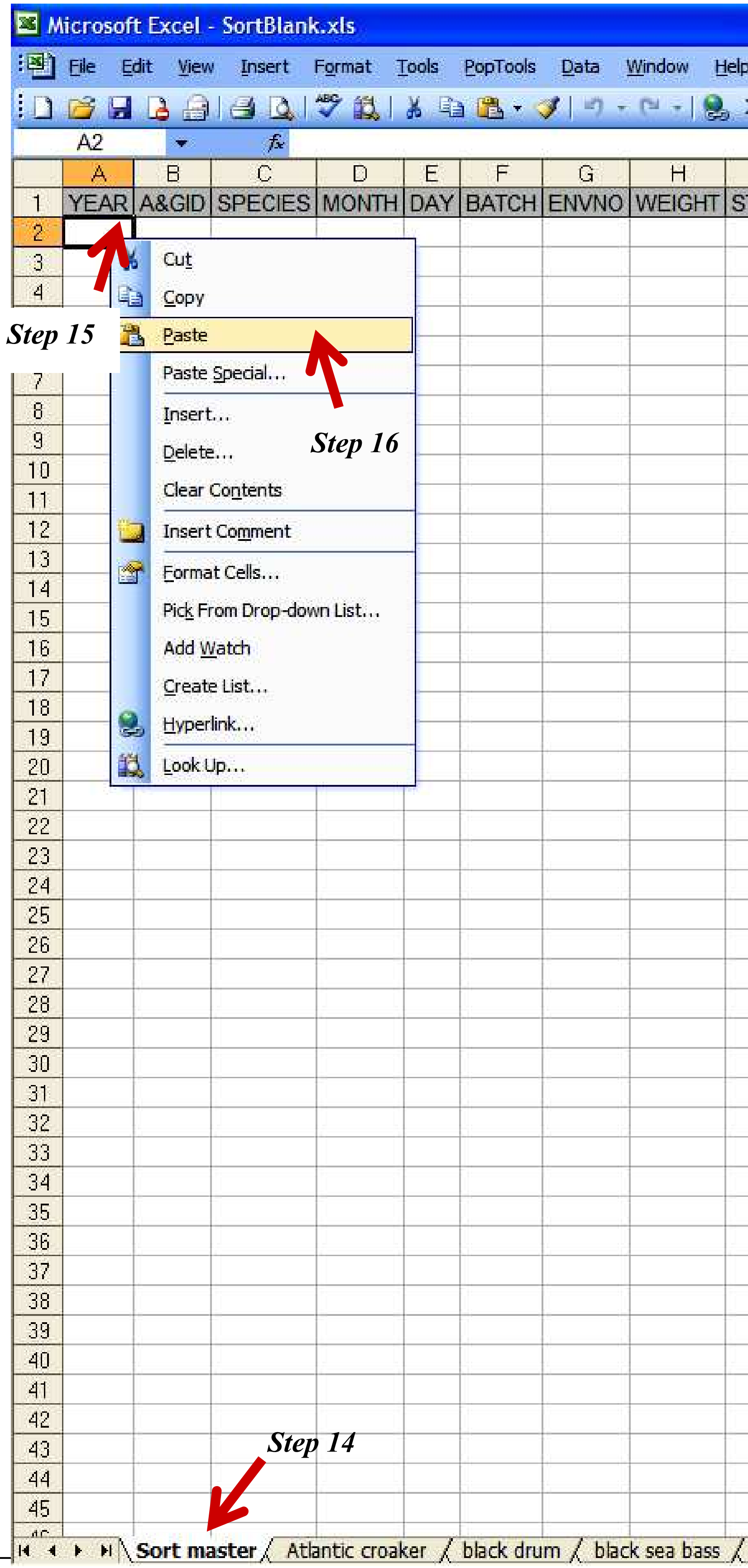
Step 15.

Right-click the first cell below the column heading **YEAR.**

Step 16.

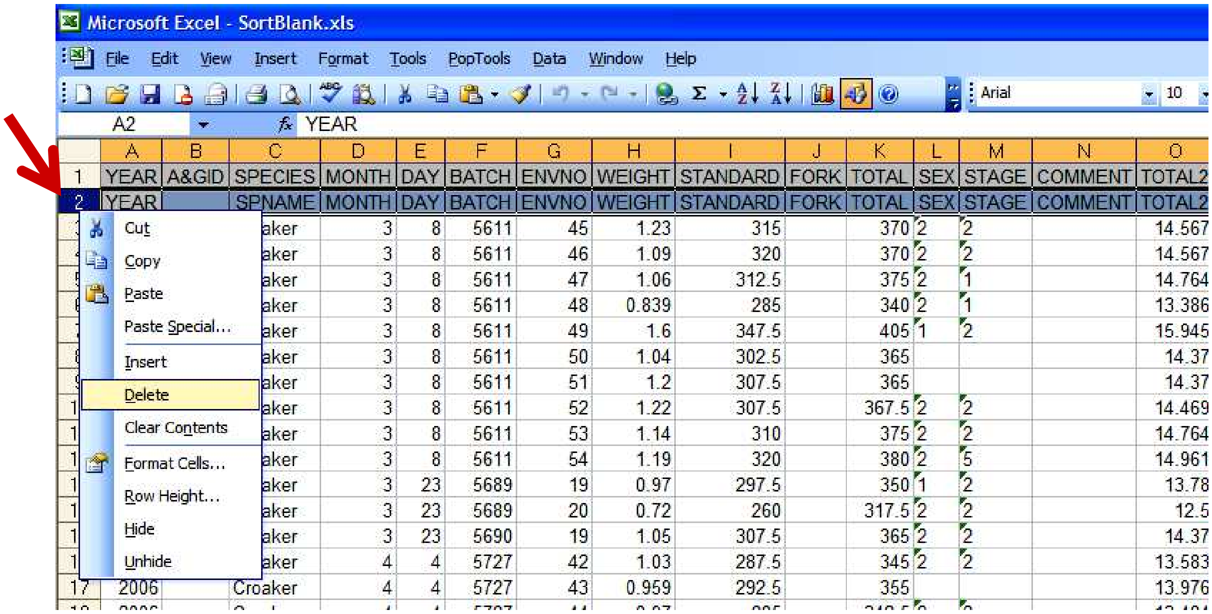
Left-click the **Paste** option to input the cells that were copied from the "sort **appropriate month year**.xls" file into this cell.

There should now be duplicate heading rows that match each other. The second row should be missing the A&G ID heading, but as long as the other column headings match-up the paste is correct.



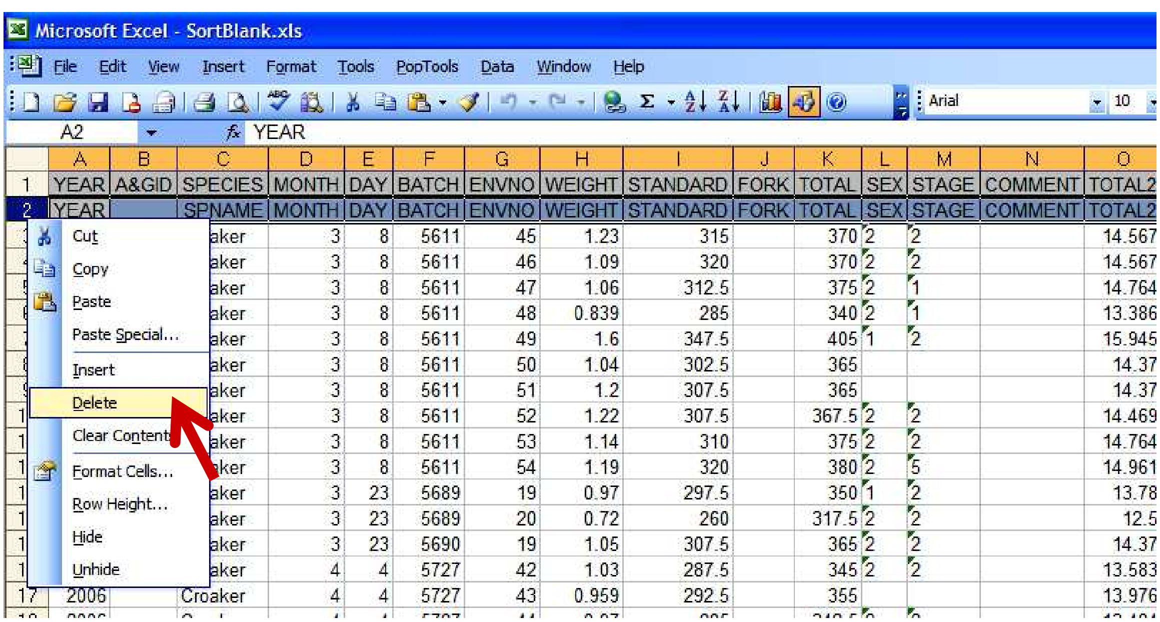
Step 17.

Right-click the second heading row at the number **2**.



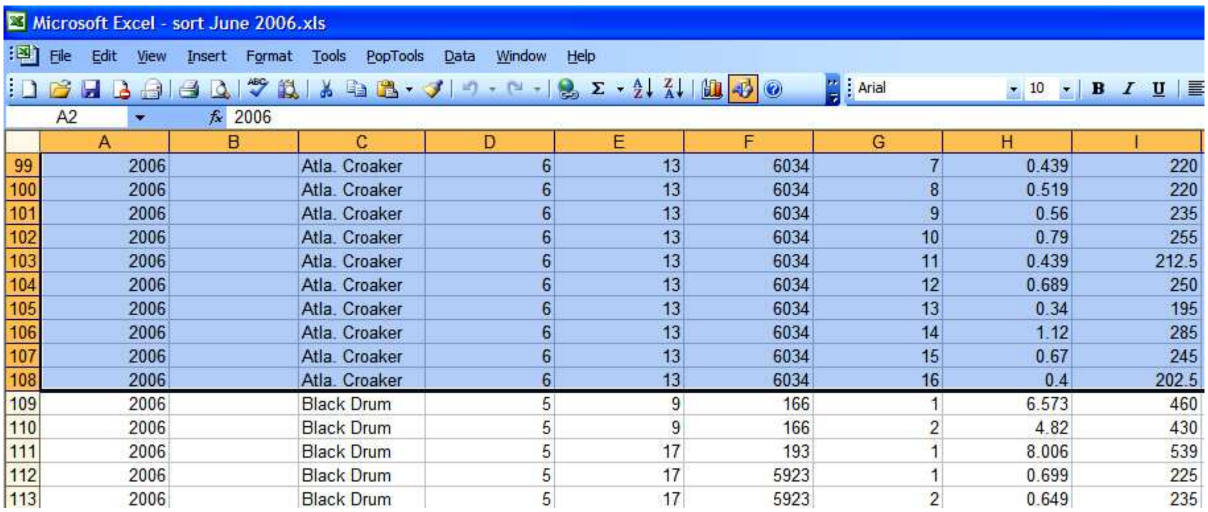
Step 18.

Left-click the **Delete** option to remove this row entirely.



Step 19.

Starting with the cell below the **YEAR** column heading, hold the left mouse button down and scroll the mouse to highlight every row and column on the spreadsheet that contains **Atlantic Croaker** data. This can also be accomplished by highlighting the rows by the numbers that lie adjacent to them. They cells may appear to only have **Croaker** written unless they have been stretched out to reveal the full name.



	A	B	C	D	E	F	G	H	I
99	2006		Atla. Croaker	6	13	6034	7	0.439	220
100	2006		Atla. Croaker	6	13	6034	8	0.519	220
101	2006		Atla. Croaker	6	13	6034	9	0.56	235
102	2006		Atla. Croaker	6	13	6034	10	0.79	255
103	2006		Atla. Croaker	6	13	6034	11	0.439	212.5
104	2006		Atla. Croaker	6	13	6034	12	0.689	250
105	2006		Atla. Croaker	6	13	6034	13	0.34	195
106	2006		Atla. Croaker	6	13	6034	14	1.12	285
107	2006		Atla. Croaker	6	13	6034	15	0.67	245
108	2006		Atla. Croaker	6	13	6034	16	0.4	202.5
109	2006		Black Drum	5	9	166	1	6.573	460
110	2006		Black Drum	5	9	166	2	4.82	430
111	2006		Black Drum	5	17	193	1	8.006	539
112	2006		Black Drum	5	17	5923	1	0.699	225
113	2006		Black Drum	5	17	5923	2	0.649	235

At the completion of June, 2006 there appears to be 107 rows containing data for Atlantic croaker. Keep in mind that row 1 contains the headings. This equates to 107 fish that were entered into the Access database and converted to the excel format.

Step 20.

Right click the mouse over the highlighted area.

Step 21.

Copy the entire highlighted portion of the spreadsheet.

Step 22.

Find the uppermost, left-handed corner of the sheet with the tab labeled "Atlantic croaker".

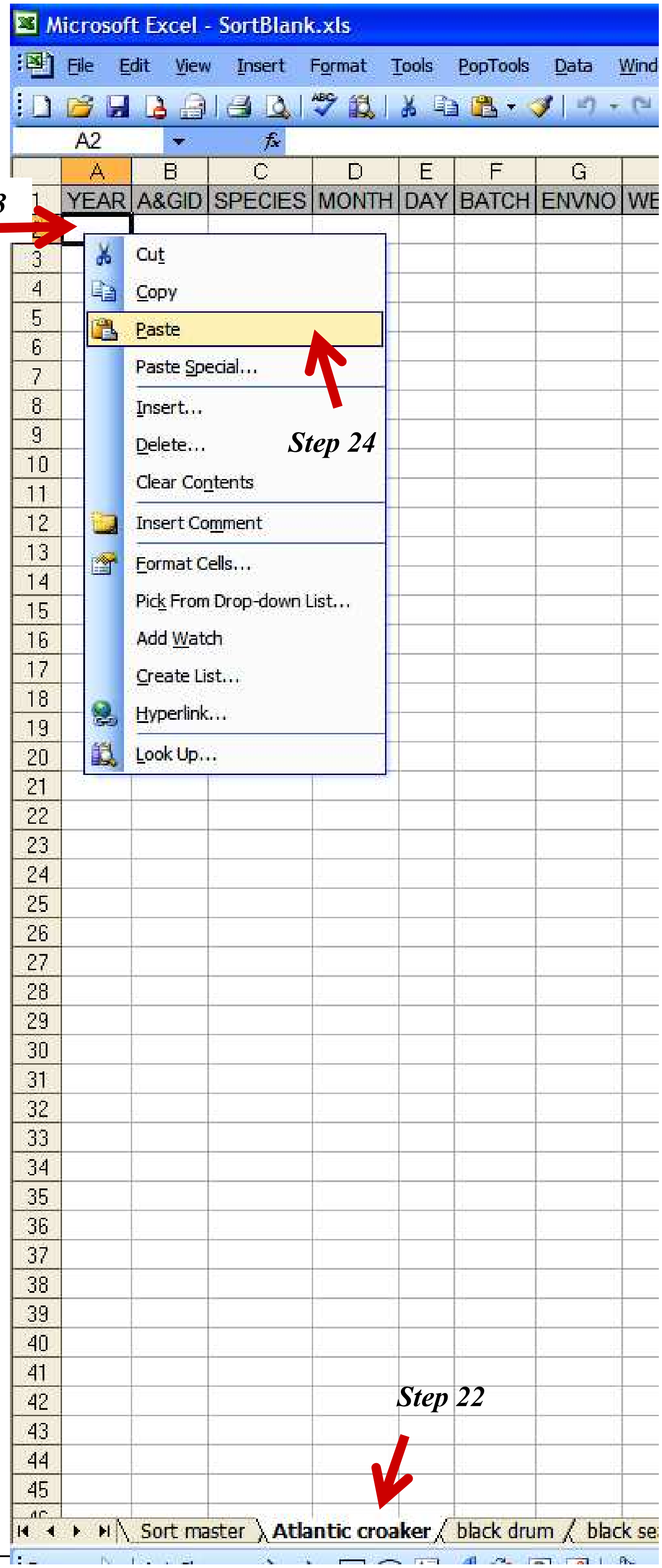
Step 23.

Right-click the first cell below the column heading **YEAR.**

Step 24.

Left-click the **Paste** option to input the cells that were copied from the **Sort master** file into this cell.

After completing the paste, check the cells to make sure that only Atlantic croaker are present on this page

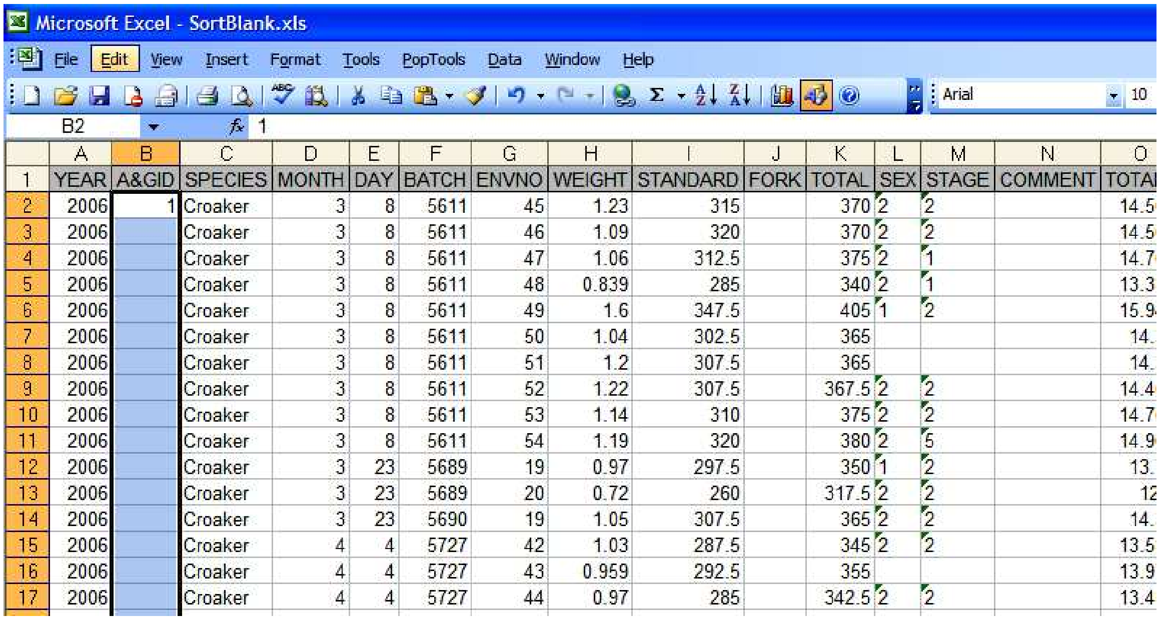


Step 25.

Type the number 1 in the first cell under the heading **A&GID.**

Step 26.

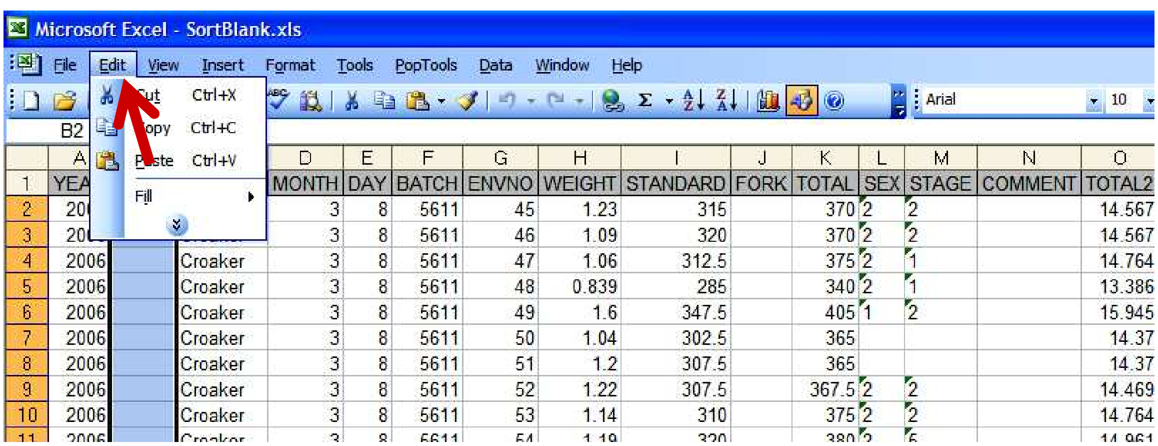
Left-click on the cell that contains the 1.
While holding the left mouse button down, scroll to highlight every empty cell that correlates to Atlantic croaker data in the **A&GID** column.



	YEAR	A&GID	SPECIES	MONTH	DAY	BATCH	ENVNO	WEIGHT	STANDARD	FORK	TOTAL	SEX	STAGE	COMMENT	TOTAl
2	2006	1	Croaker	3	8	5611	45	1.23	315		370	2	2		14.5
3	2006		Croaker	3	8	5611	46	1.09	320		370	2	2		14.5
4	2006		Croaker	3	8	5611	47	1.06	312.5		375	2	1		14.7
5	2006		Croaker	3	8	5611	48	0.839	285		340	2	1		13.3
6	2006		Croaker	3	8	5611	49	1.6	347.5		405	1	2		15.9
7	2006		Croaker	3	8	5611	50	1.04	302.5		365				14.
8	2006		Croaker	3	8	5611	51	1.2	307.5		365				14.
9	2006		Croaker	3	8	5611	52	1.22	307.5		367.5	2	2		14.4
10	2006		Croaker	3	8	5611	53	1.14	310		375	2	2		14.7
11	2006		Croaker	3	8	5611	54	1.19	320		380	2	5		14.9
12	2006		Croaker	3	23	5689	19	0.97	297.5		350	1	2		13.
13	2006		Croaker	3	23	5689	20	0.72	260		317.5	2	2		12
14	2006		Croaker	3	23	5690	19	1.05	307.5		365	2	2		14.
15	2006		Croaker	4	4	5727	42	1.03	287.5		345	2	2		13.5
16	2006		Croaker	4	4	5727	43	0.959	292.5		355				13.9
17	2006		Croaker	4	4	5727	44	0.97	285		342.5	2	2		13.4

Step 27.

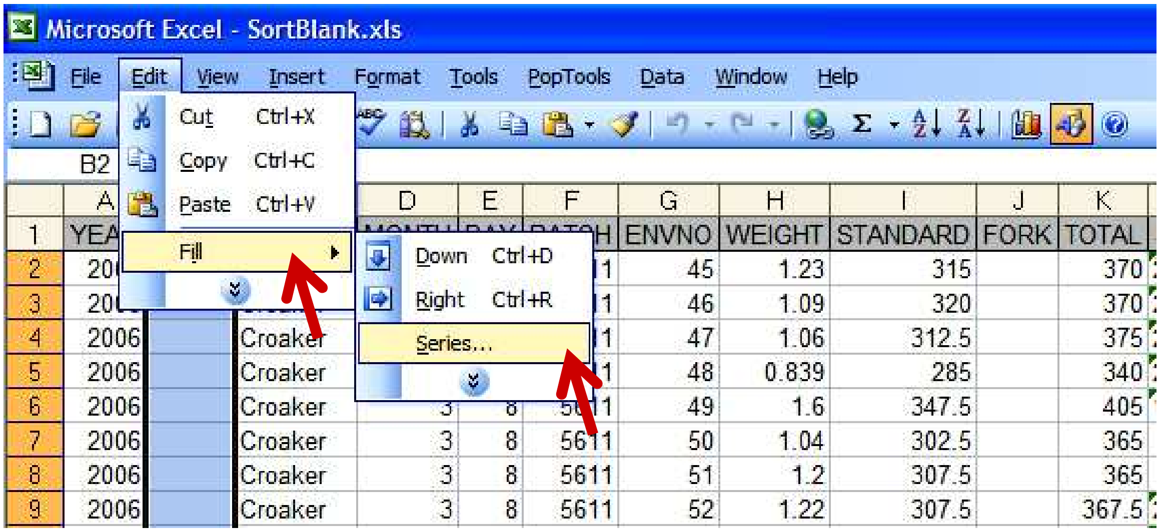
Left-click the **Edit** tool to bring up the **Fill** option.



	YEAR	A&GID	SPECIES	MONTH	DAY	BATCH	ENVNO	WEIGHT	STANDARD	FORK	TOTAL	SEX	STAGE	COMMENT	TOTAL2
2				3	8	5611	45	1.23	315		370	2	2		14.567
3				3	8	5611	46	1.09	320		370	2	2		14.567
4	2006		Croaker	3	8	5611	47	1.06	312.5		375	2	1		14.764
5	2006		Croaker	3	8	5611	48	0.839	285		340	2	1		13.386
6	2006		Croaker	3	8	5611	49	1.6	347.5		405	1	2		15.945
7	2006		Croaker	3	8	5611	50	1.04	302.5		365				14.37
8	2006		Croaker	3	8	5611	51	1.2	307.5		365				14.37
9	2006		Croaker	3	8	5611	52	1.22	307.5		367.5	2	2		14.469
10	2006		Croaker	3	8	5611	53	1.14	310		375	2	2		14.764

Step 28.

Left-click the **Fill** option to bring up the **Series** option.

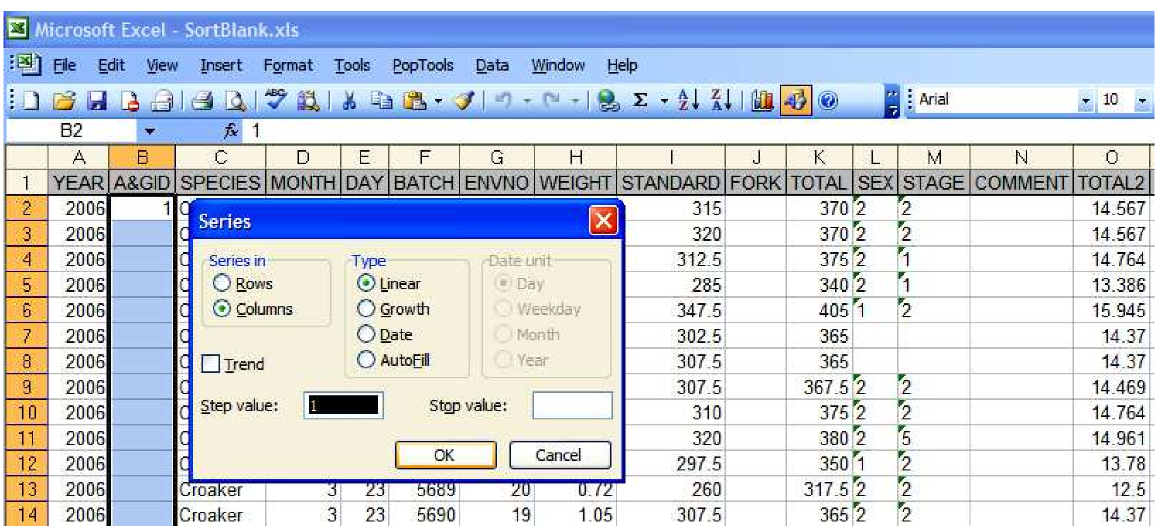


Step 29.

Left-click the **Series** option to bring up the **Series** option box.

Select for

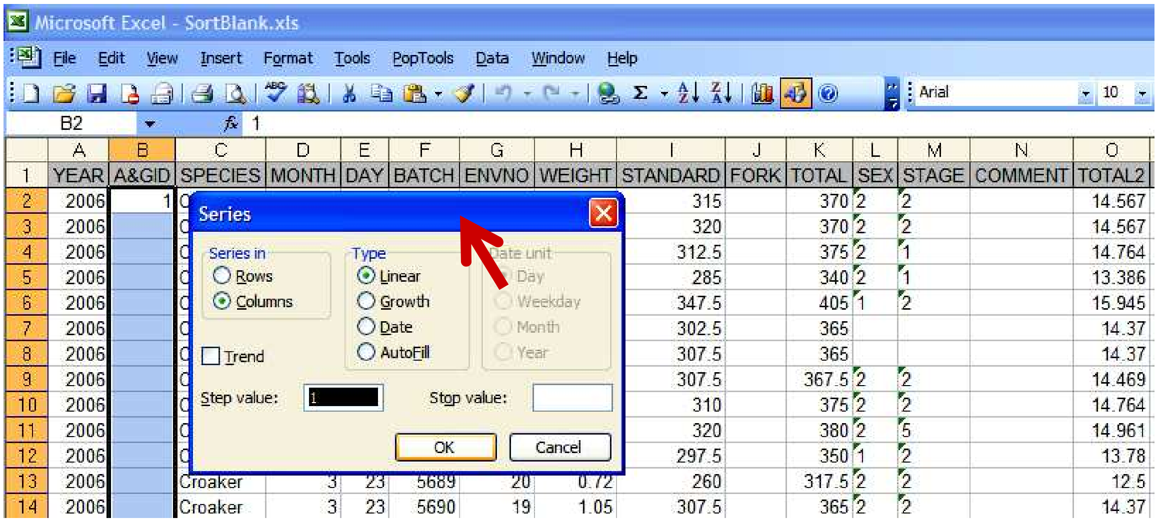
Series in: **Columns**
Type: **Linear**
Step value: **1**

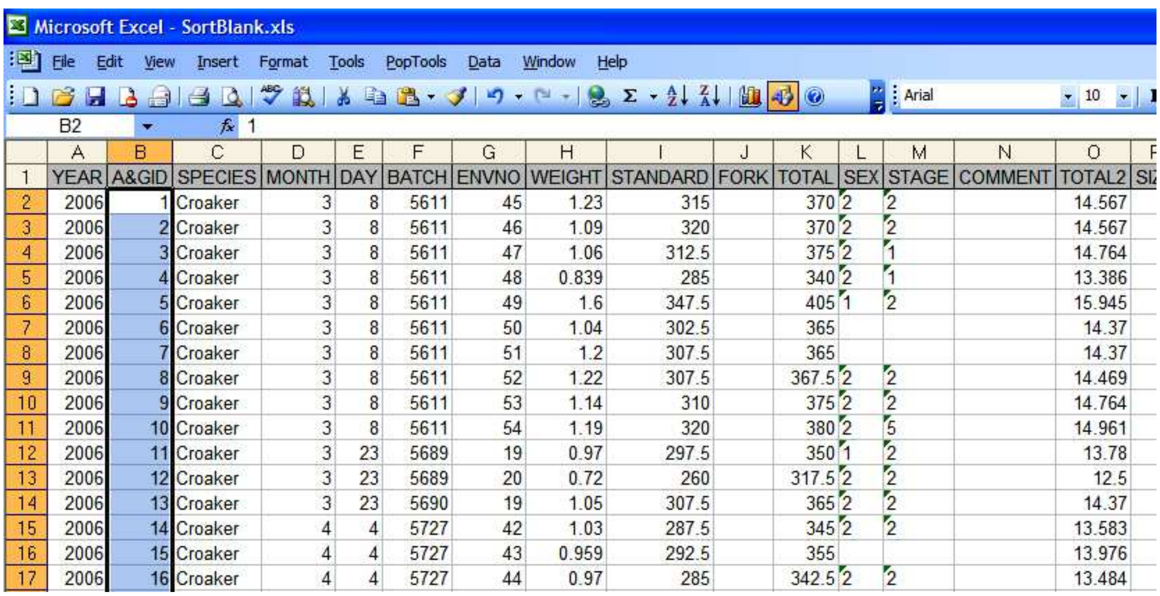


Step 30.

Left-click **OK**.

This will fill the column series with sequential numbers beginning with the number 1.





	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	YEAR	A&GID	SPECIES	MONTH	DAY	BATCH	ENVNO	WEIGHT	STANDARD	FORK	TOTAL	SEX	STAGE	COMMENT	TOTAL2
2	2006	1	Croaker	3	8	5611	45	1.23	315		370	2	2		14.567
3	2006	2	Croaker	3	8	5611	46	1.09	320		370	2	2		14.567
4	2006	3	Croaker	3	8	5611	47	1.06	312.5		375	2	1		14.764
5	2006	4	Croaker	3	8	5611	48	0.839	285		340	2	1		13.386
6	2006	5	Croaker	3	8	5611	49	1.6	347.5		405	1	2		15.945
7	2006	6	Croaker	3	8	5611	50	1.04	302.5		365				14.37
8	2006	7	Croaker	3	8	5611	51	1.2	307.5		365				14.37
9	2006	8	Croaker	3	8	5611	52	1.22	307.5		367.5	2	2		14.469
10	2006	9	Croaker	3	8	5611	53	1.14	310		375	2	2		14.764
11	2006	10	Croaker	3	8	5611	54	1.19	320		380	2	5		14.961
12	2006	11	Croaker	3	23	5689	19	0.97	297.5		350	1	2		13.78
13	2006	12	Croaker	3	23	5689	20	0.72	260		317.5	2	2		12.5
14	2006	13	Croaker	3	23	5690	19	1.05	307.5		365	2	2		14.37
15	2006	14	Croaker	4	4	5727	42	1.03	287.5		345	2	2		13.583
16	2006	15	Croaker	4	4	5727	43	0.959	292.5		355				13.976
17	2006	16	Croaker	4	4	5727	44	0.97	285		342.5	2	2		13.484

Step 31.

Go back to **Step 19** and continue to copy and paste each species from the **Sort master** tab into their appropriate sheet according to the tabs at the bottom of the "SortBlank.xls" file. Black Drum will be the next in order. Assign each fish in the species set an A&GID number beginning with the number 1.

Step 32.

After completing the movement of the data sets to their individual sheets, minimize the"SortBlank.xls" file.

Step 33.

Maximize the "sort **appropriate month year**.xls" file.

Step 34.

Close this file. Do not save any changes.

Step 35.

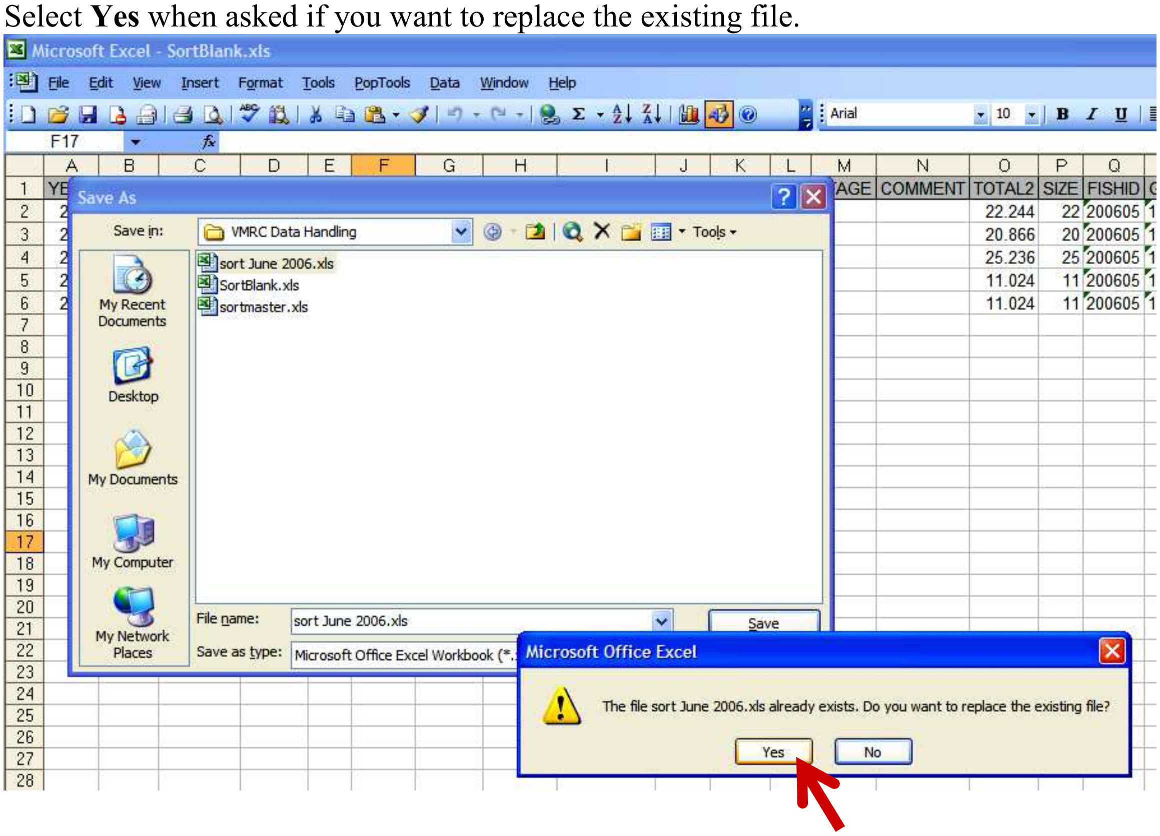
Maximize the"SortBlank.xls" file.

Step 36.

Save the "SortBlank.xls" as the new "sort **appropriate month year**.xls"

Step 37.

Select **Yes** when asked if you want to replace the existing file.

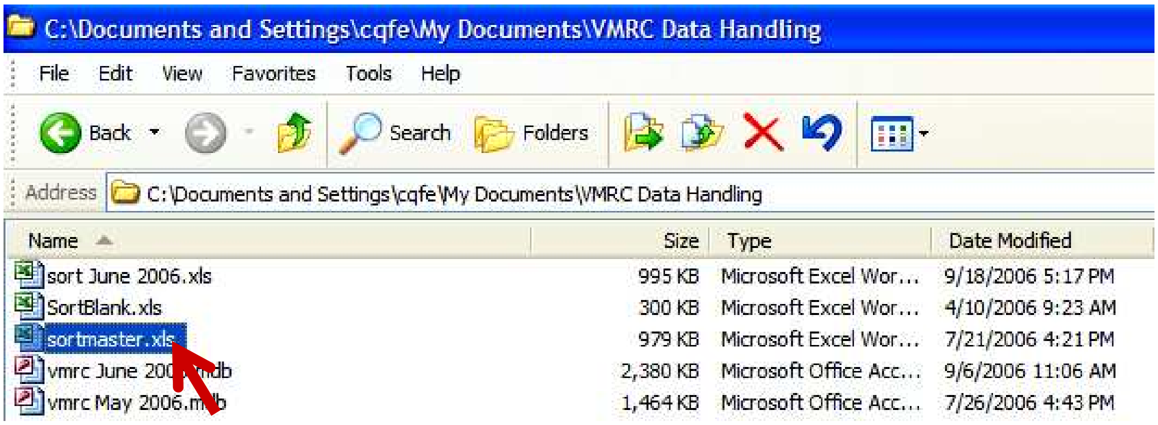


Step 38.

Go back to the "**J:\everyone\Ageinglab\data\\<u>appropriate year</u>\all**" folder.

Step 38.

Open the "**sortmaster.xls**"file



Step 39.

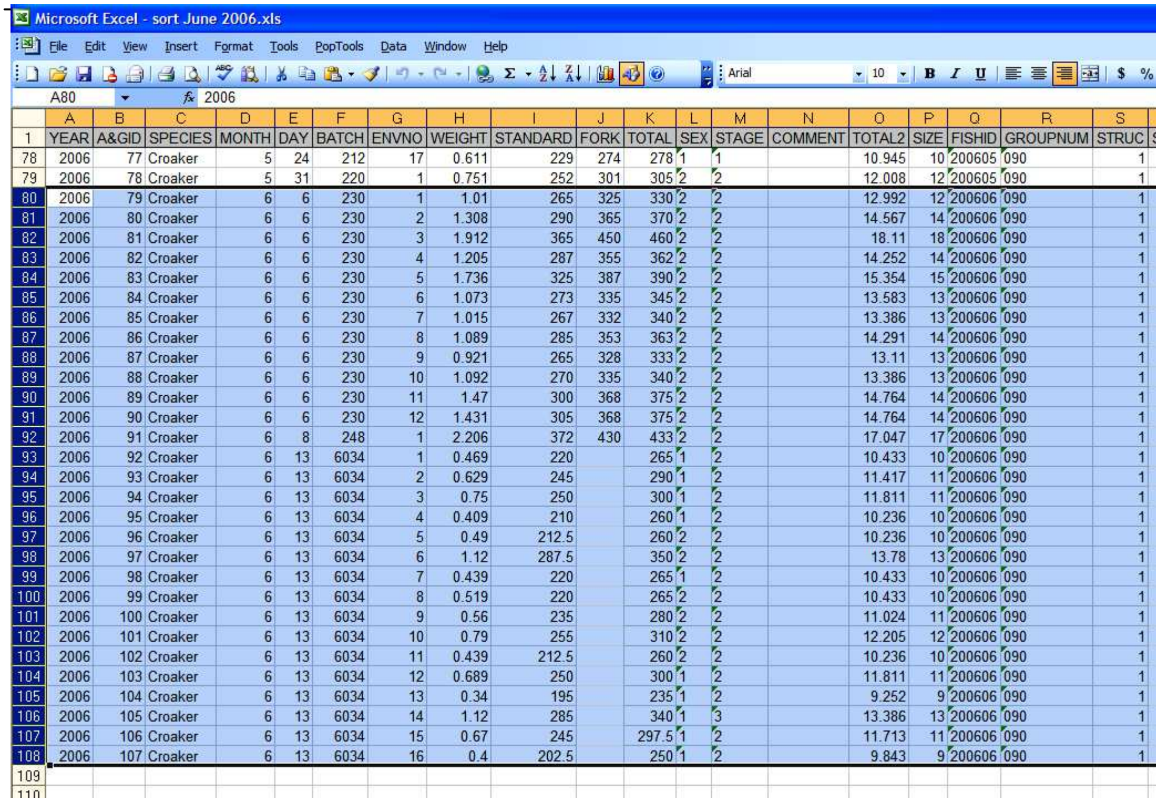
Maximize the "sort **appropriate month year**.xls" file.

Step 40.

Starting with the Atlantic croaker sheet find the fish that have the number 6 in the column for **MONTH.**

Step 41.

Hold the left mouse button down and scroll the mouse to highlight every row and column on the spreadsheet that contains **Atlantic Croaker** data with the number 6 in the **MONTH** column. This can also be accomplished by highlighting the rows by the numbers that lie adjacent to them. **Do not** include any of the fish from the other months.



Microsoft Excel - sort June 2006.xls

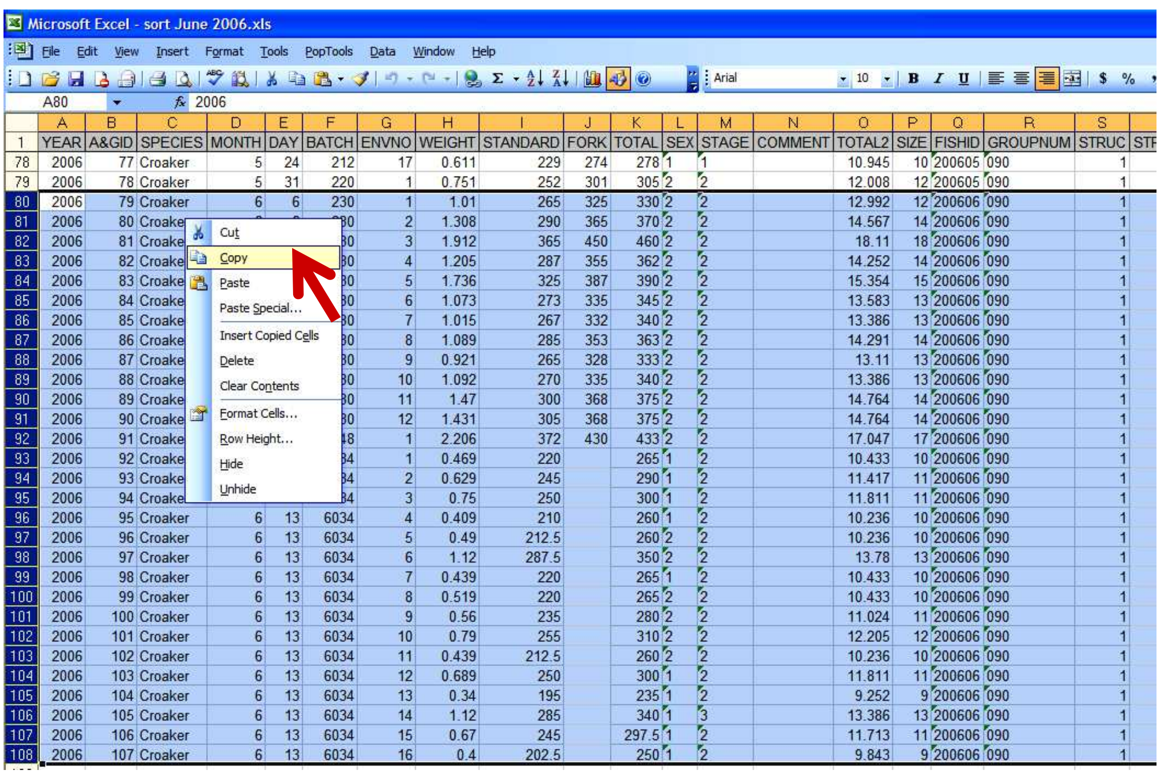
File Edit View Insert Format Tools PopTools Data Window Help

A80 | 2006

	YEAR	A&GID	SPECIES	MONTH	DAY	BATCH	ENVNO	WEIGHT	STANDARD	FORK	TOTAL	SEX	STAGE	COMMENT	TOTAL2	SIZE	FISHID	GROUPNUM	STRUC
78	2006	77	Croaker	5	24	212	17	0.611	229	274	278	1	1		10.945	10	200605	090	1
79	2006	78	Croaker	5	31	220	1	0.751	252	301	305	2	2		12.008	12	200605	090	1
80	2006	79	Croaker	6	6	230	1	1.01	265	325	330	2	2		12.992	12	200606	090	1
81	2006	80	Croaker	6	6	230	2	1.308	290	365	370	2	2		14.567	14	200606	090	1
82	2006	81	Croaker	6	6	230	3	1.912	365	450	460	2	2		18.11	18	200606	090	1
83	2006	82	Croaker	6	6	230	4	1.205	287	355	362	2	2		14.252	14	200606	090	1
84	2006	83	Croaker	6	6	230	5	1.736	325	387	390	2	2		15.354	15	200606	090	1
85	2006	84	Croaker	6	6	230	6	1.073	273	335	345	2	2		13.583	13	200606	090	1
86	2006	85	Croaker	6	6	230	7	1.015	267	332	340	2	2		13.386	13	200606	090	1
87	2006	86	Croaker	6	6	230	8	1.089	285	353	363	2	2		14.291	14	200606	090	1
88	2006	87	Croaker	6	6	230	9	0.921	265	328	333	2	2		13.11	13	200606	090	1
89	2006	88	Croaker	6	6	230	10	1.092	270	335	340	2	2		13.386	13	200606	090	1
90	2006	89	Croaker	6	6	230	11	1.47	300	368	375	2	2		14.764	14	200606	090	1
91	2006	90	Croaker	6	6	230	12	1.431	305	368	375	2	2		14.764	14	200606	090	1
92	2006	91	Croaker	6	8	248	1	2.206	372	430	433	2	2		17.047	17	200606	090	1
93	2006	92	Croaker	6	13	6034	1	0.469	220		265	1	2		10.433	10	200606	090	1
94	2006	93	Croaker	6	13	6034	2	0.629	245		290	1	2		11.417	11	200606	090	1
95	2006	94	Croaker	6	13	6034	3	0.75	250		300	1	2		11.811	11	200606	090	1
96	2006	95	Croaker	6	13	6034	4	0.409	210		260	1	2		10.236	10	200606	090	1
97	2006	96	Croaker	6	13	6034	5	0.49	212.5		260	2	2		10.236	10	200606	090	1
98	2006	97	Croaker	6	13	6034	6	1.12	287.5		350	2	2		13.78	13	200606	090	1
99	2006	98	Croaker	6	13	6034	7	0.439	220		265	1	2		10.433	10	200606	090	1
100	2006	99	Croaker	6	13	6034	8	0.519	220		265	2	2		10.433	10	200606	090	1
101	2006	100	Croaker	6	13	6034	9	0.56	235		280	2	2		11.024	11	200606	090	1
102	2006	101	Croaker	6	13	6034	10	0.79	255		310	2	2		12.205	12	200606	090	1
103	2006	102	Croaker	6	13	6034	11	0.439	212.5		260	2	2		10.236	10	200606	090	1
104	2006	103	Croaker	6	13	6034	12	0.689	250		300	1	2		11.811	11	200606	090	1
105	2006	104	Croaker	6	13	6034	13	0.34	195		235	1	2		9.252	9	200606	090	1
106	2006	105	Croaker	6	13	6034	14	1.12	285		340	1	3		13.386	13	200606	090	1
107	2006	106	Croaker	6	13	6034	15	0.67	245		297.5	1	2		11.713	11	200606	090	1
108	2006	107	Croaker	6	13	6034	16	0.4	202.5		250	1	2		9.843	9	200606	090	1

Step 42.

Right-click the highlighted area and copy the data.



Minimize the "sort **appropriate month year**.xls" file.

Step 43.

Maximize the "**sortmaster.xls**" file

Step 44.

Find the sheet with the tab marked **Atlantic croaker** in the "**sortmaster.xls**" file.

Step 45.

Open the sheet.

Step 46.

Step 46

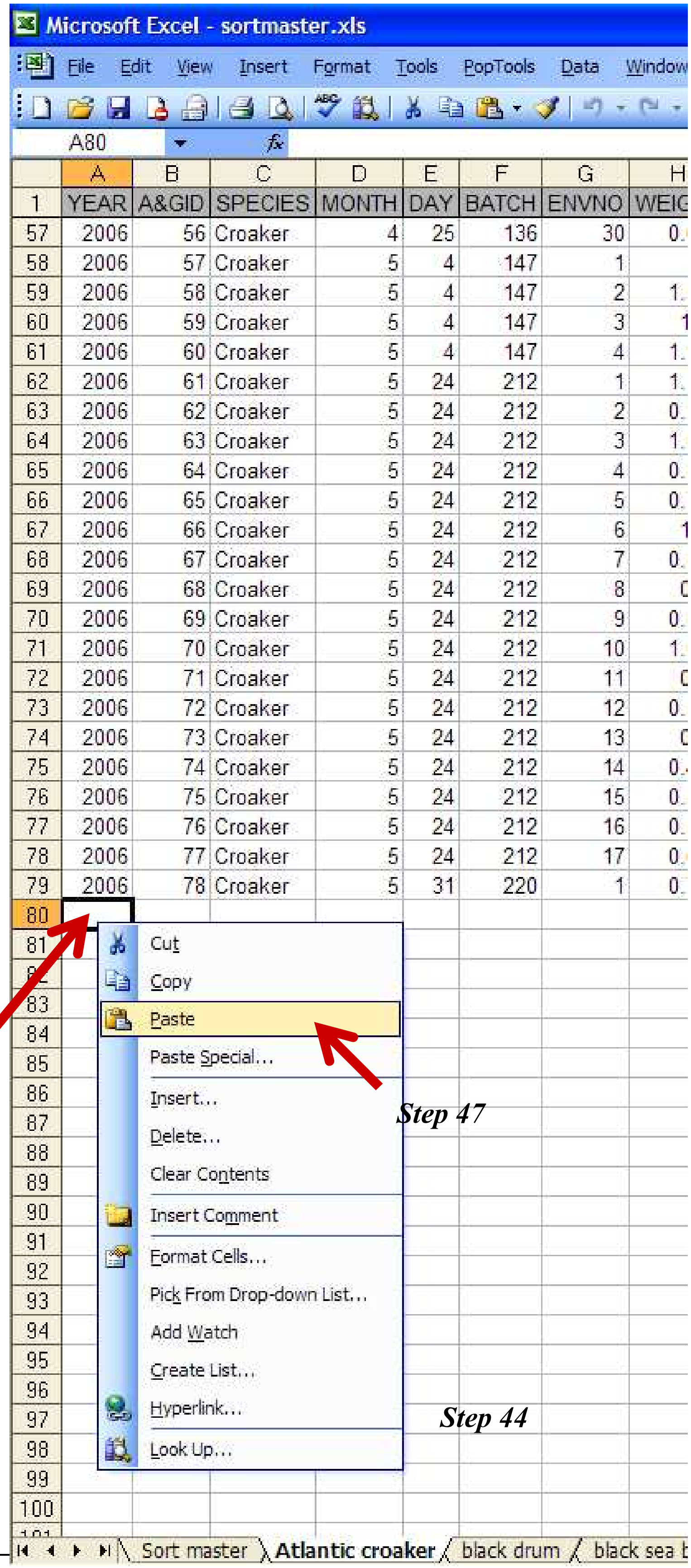
Right-click the empty cell

below the last entry in the **YEAR**

column.

Step 47.

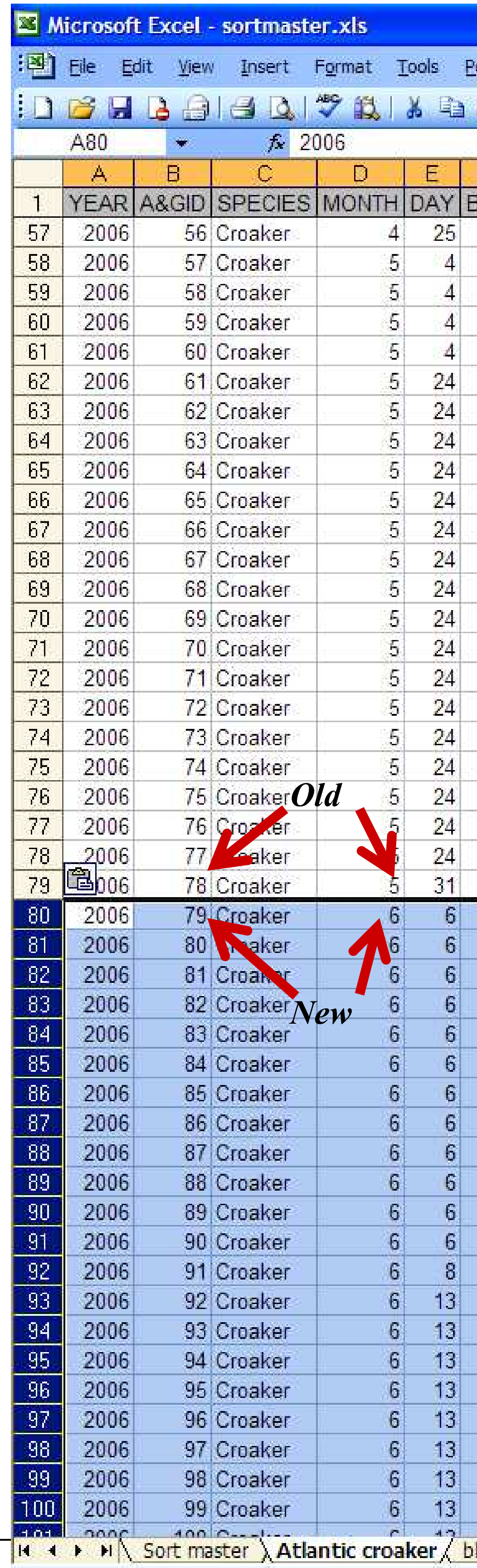
Paste the data that was copied from



	A	B	C	D	E	F	G	H
1	YEAR	A&GID	SPECIES	MONTH	DAY	BATCH	ENVNO	WEIG
57	2006	56	Croaker	4	25	136	30	0.
58	2006	57	Croaker	5	4	147	1	
59	2006	58	Croaker	5	4	147	2	1.
60	2006	59	Croaker	5	4	147	3	1
61	2006	60	Croaker	5	4	147	4	1.
62	2006	61	Croaker	5	24	212	1	1.
63	2006	62	Croaker	5	24	212	2	0.
64	2006	63	Croaker	5	24	212	3	1.
65	2006	64	Croaker	5	24	212	4	0.
66	2006	65	Croaker	5	24	212	5	0.
67	2006	66	Croaker	5	24	212	6	1
68	2006	67	Croaker	5	24	212	7	0.
69	2006	68	Croaker	5	24	212	8	C
70	2006	69	Croaker	5	24	212	9	0.
71	2006	70	Croaker	5	24	212	10	1.
72	2006	71	Croaker	5	24	212	11	C
73	2006	72	Croaker	5	24	212	12	0.
74	2006	73	Croaker	5	24	212	13	C
75	2006	74	Croaker	5	24	212	14	0.
76	2006	75	Croaker	5	24	212	15	0.
77	2006	76	Croaker	5	24	212	16	0.
78	2006	77	Croaker	5	24	212	17	0.
79	2006	78	Croaker	5	31	220	1	0.

the "sort **appropriate month year**.xls

file.



	A	B	C	D	E
1	YEAR	A&GID	SPECIES	MONTH	DAY
57	2006	56	Croaker	4	25
58	2006	57	Croaker	5	4
59	2006	58	Croaker	5	4
60	2006	59	Croaker	5	4
61	2006	60	Croaker	5	4
62	2006	61	Croaker	5	24
63	2006	62	Croaker	5	24
64	2006	63	Croaker	5	24
65	2006	64	Croaker	5	24
66	2006	65	Croaker	5	24
67	2006	66	Croaker	5	24
68	2006	67	Croaker	5	24
69	2006	68	Croaker	5	24
70	2006	69	Croaker	5	24
71	2006	70	Croaker	5	24
72	2006	71	Croaker	5	24
73	2006	72	Croaker	5	24
74	2006	73	Croaker	5	24
75	2006	74	Croaker	5	24
76	2006	75	Croaker	5	24
77	2006	76	Croaker	5	24
78	2006	77	Croaker	5	24
79	2006	78	Croaker	5	31
80	2006	79	Croaker	6	6
81	2006	80	Croaker	6	6
82	2006	81	Croaker	6	6
83	2006	82	Croaker	6	6
84	2006	83	Croaker	6	6
85	2006	84	Croaker	6	6
86	2006	85	Croaker	6	6
87	2006	86	Croaker	6	6
88	2006	87	Croaker	6	6
89	2006	88	Croaker	6	6
90	2006	89	Croaker	6	6
91	2006	90	Croaker	6	6
92	2006	91	Croaker	6	8
93	2006	92	Croaker	6	13
94	2006	93	Croaker	6	13
95	2006	94	Croaker	6	13
96	2006	95	Croaker	6	13
97	2006	96	Croaker	6	13
98	2006	97	Croaker	6	13
99	2006	98	Croaker	6	13
100	2006	99	Croaker	6	13

Step 48.

Check to make sure the last entry for the "**sortmaster.xls**" file matches up sequentially to the first new entry from the "**sort appropriate month year.xls"** file in the column that designates the **A&GID.**

In this case the ID numbers are **A&GID 78** for month 5 and **A&GID 79** for month 6.

When the numbers fall into sequential order, this means that the data set is in complete order.

In the case of mis-sequenced numbers, the new and old data sets need to be checked for discrepancies.

Step 49.

Repeat steps 40-48 to transfer the appropriate month's data for each of the remaining species from the "**sort appropriate month year.xls"** file to the "**sortmaster.xls**" file**.**

Step50.

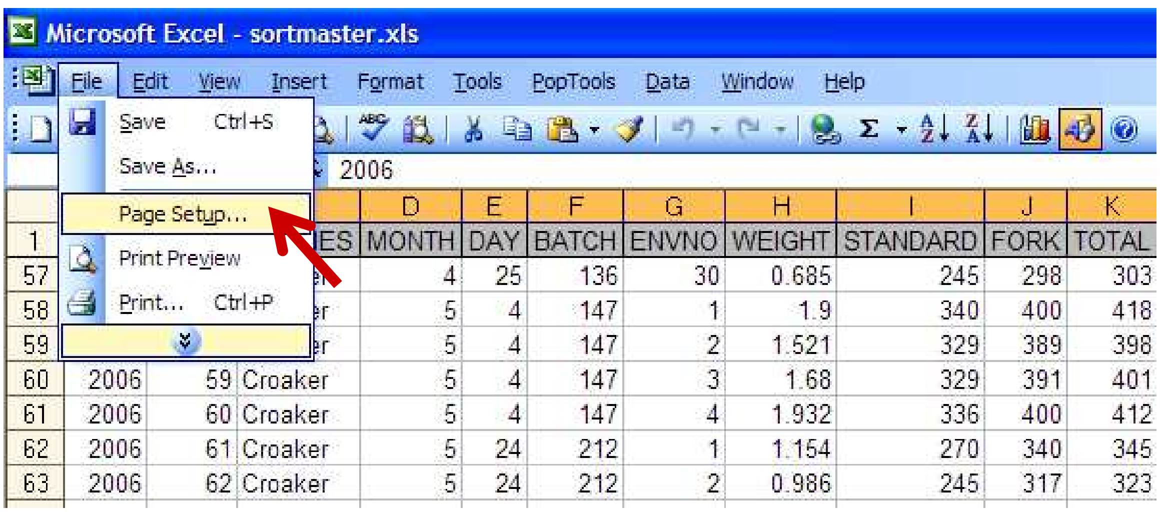
Save all the changes to the "**sortmaster.xls**" file upon completion of the transfers.

Step51.

Print the new months data for each species from the "**sortmaster.xls**" file using the following format.

Step 51a.

Use the File tool to access the **Page Setup** option

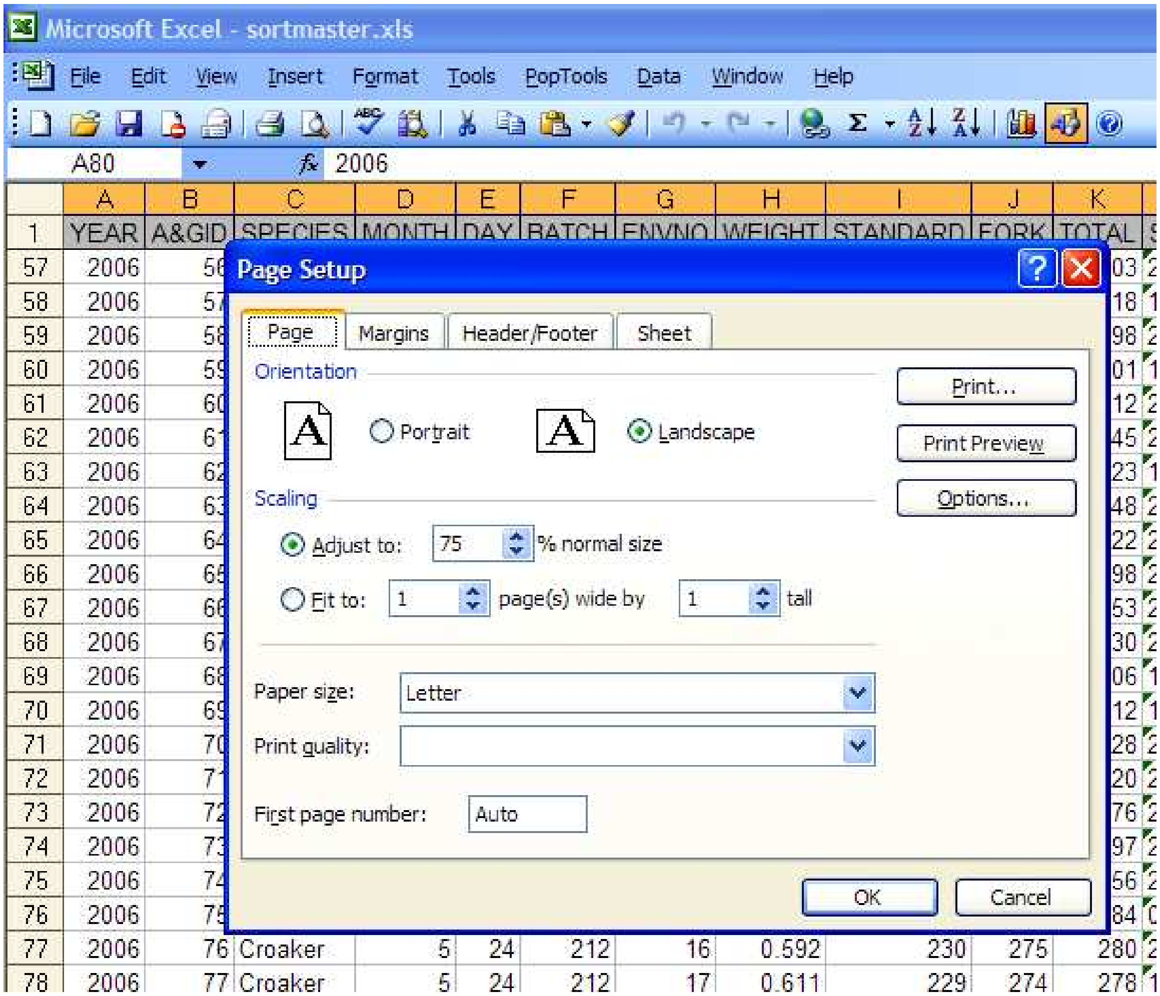


Step 51b.

On the Page Setup screen select for the following options.

Page tab

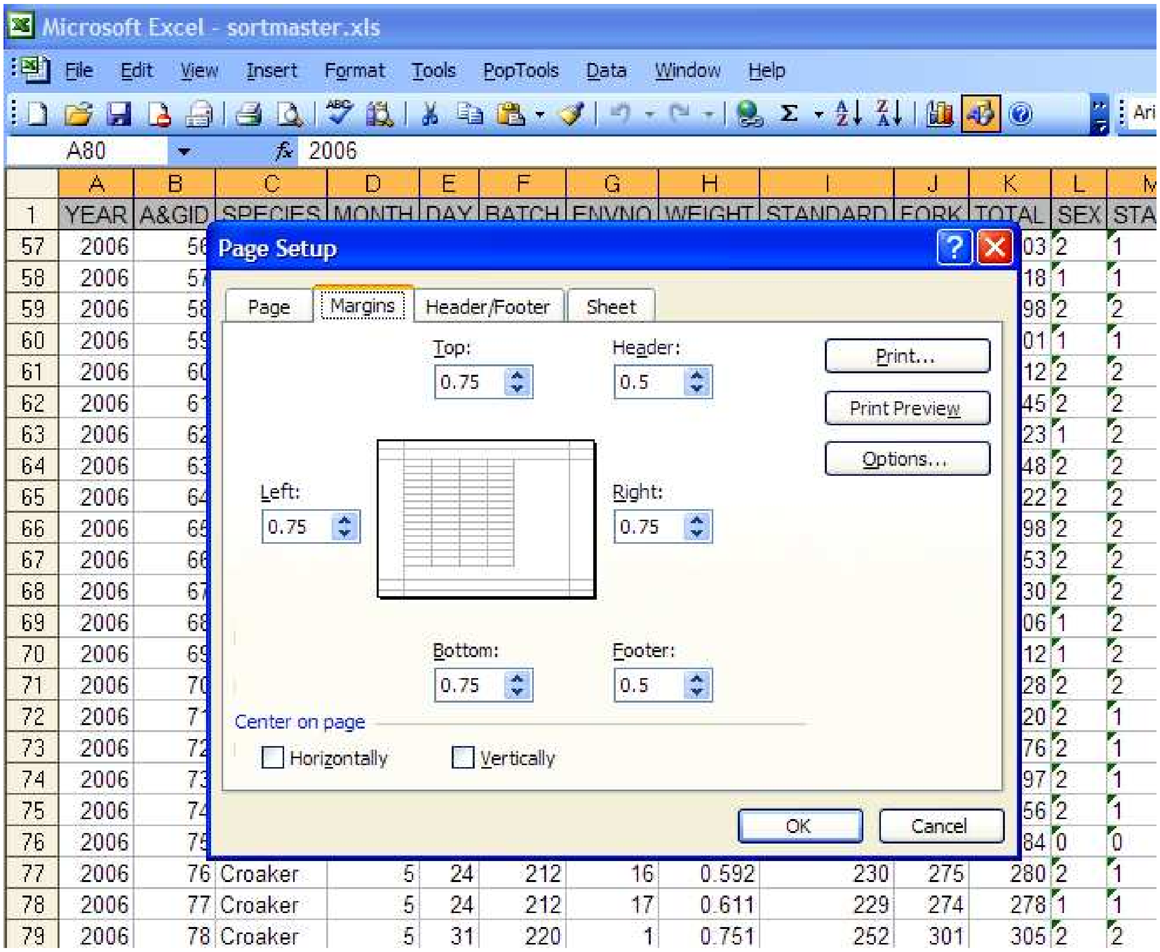
Orientation: Landscape
Scaling: Adjust to 75% normal size
Paper size: Letter
First page number: Auto



Step 51c.

Margins tab

Top:	0.75	**Header**:	0.5
Bottom:	0.75	**Footer**:	0.5
Left:	0.75		
Right:	0.75		

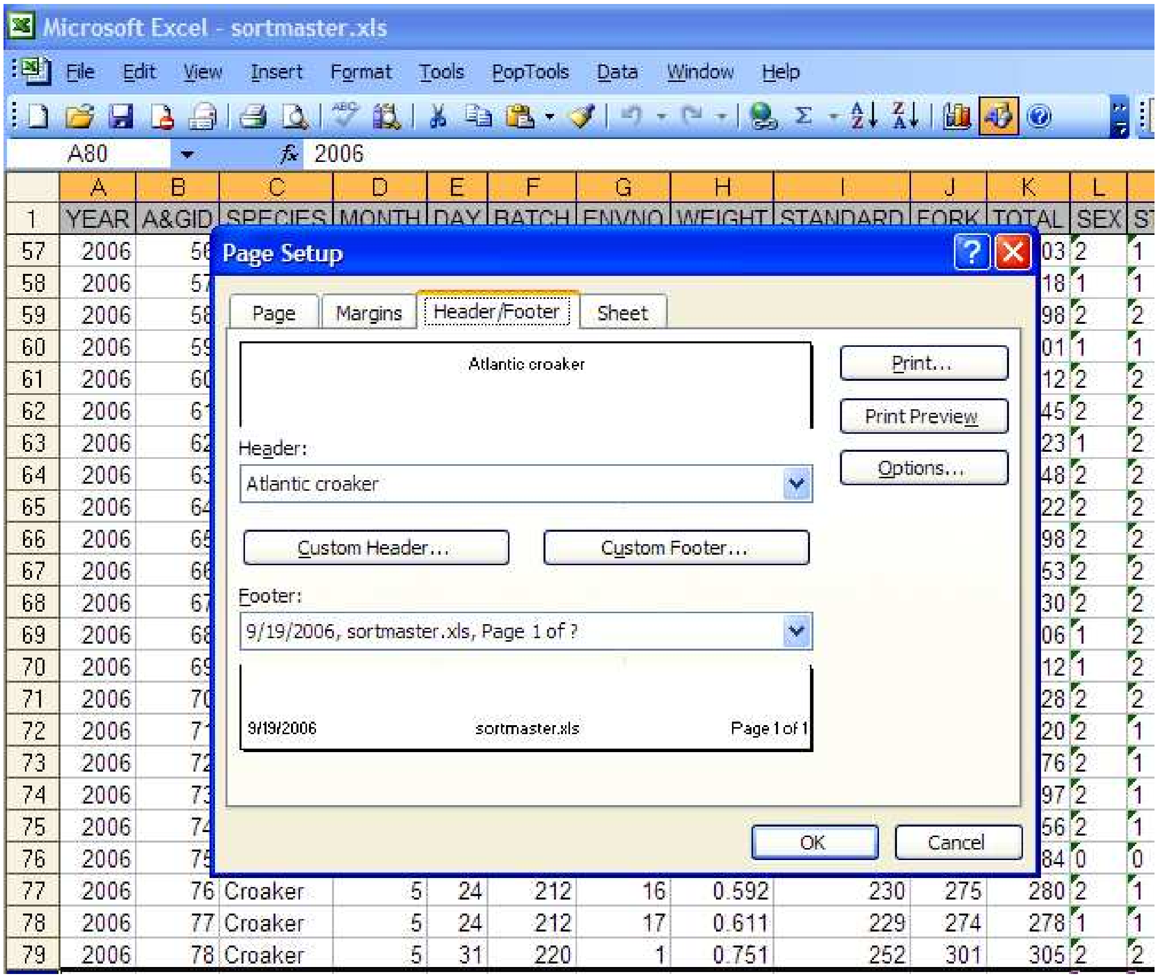


Step 51d.

Header/Footer tab

Header: Species Name (exp. Atlantic croaker)

Footer: Date (xx/xx/xxxx format), sortmaster.xls, Page 1 of ?



Step 51e.

Sheet tab

Print titles

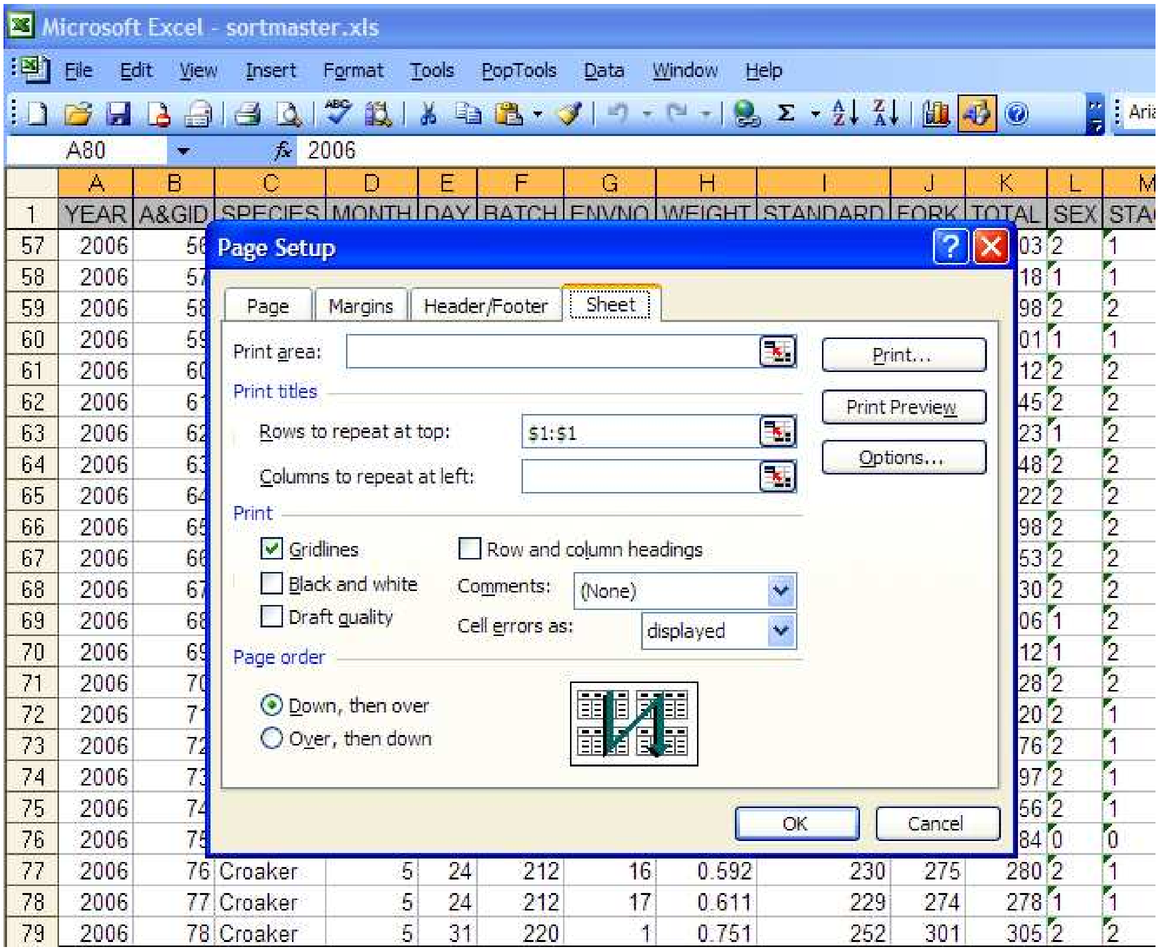
Rows to repeat at top: **$1:$1**

Print

☑ Gridlines

Page order

Down, then over



Step52.

Put the printed copies under the individual species listings in the appropriate binder.

Step53.

Close the"**sortmaster.xls**" file. Remember to save all changes.

Step54.

Close the **"sort appropriate month year.xls"** file. Remember to save all changes.

This completes Part 2 of VMRC Data Handling One.